Knowledge in Building with Nature pilot projects

A Case Study of the Sand Engine

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Preface

After more than 20 years of education, the end is in sight for me. I am looking forward to finally applying all I have learned in these years and, hopefully, leaving a positive mark on the world.

I want to thank Gerald Jan for the daily morning motivations, the kind words and the gentle guidance. The way you approach your work and research was a breath of fresh air for me and I enjoyed our early morning chats with Jort and Eleni a lot. Thank you for being companions in an otherwise very individual thesis process.

Furthermore, I want to thank Jill for her patience, the good coffees, the lovely conversations on the second floor and the help with bringing structure to the chaos. Often our meetings would stray from the thesis to all kinds of topics and your unique points of view have taught me a lot. I see that you put a lot of effort into me and this thesis and I really appreciate the level of personal involvement you have shown me.

Lastly I want to thank my family, girlfriend and friends for their unending support, their patience and their very welcome distractions.

G.E.W. Van den Bosch
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Summary

This research aims to answer the research question: Based on the Sand Engine, how can the use and spread of knowledge acquired in Building with Nature pilot projects be improved? The end results are recommendations for new Building with Nature (BwN) pilot projects on ways to improve the knowledge use and spread in and from these projects. To achieve this, a literature review is performed, interviews are done and two System Dynamics models are developed. These methods were all applied to the subject of the case study of this research: the Sand Engine.

The knowledge in the Sand Engine pilot project was primarily acquired through two of the four knowledge programs run as part of the project, namely: The Rijkswaterstaat monitoring program and NatureCoast. The first program represents the efforts by Rijkswaterstaat to monitor the goals of the Sand Engine and the effects it has on its environment. The second program was a research project funded by the Dutch Science Council (NWO) to monitor and learn from the biophysical evolution of the Sand Engine and about its governance. The knowledge from these programs was used by Rijkswaterstaat to iteratively adapt the project to its context, to ensure the safety of swimmers, surfers and day-trippers in the water around the Sand Engine and to evaluate and change the monitoring program if necessary. This relation was recognised through the interviews, literature review and one of the System Dynamics models, the Pilot Individual Evolution model. Lastly, the acquired scientific knowledge on the dynamic biophysical, ecological and governance systems was used by the involved PhD and post-doc researchers from NatureCoast, who published their findings in the scientific literature where worldwide dissemination can be achieved.

The spread of this acquired knowledge occurred as Rijkswaterstaat, the operational arm of the ministry of Infrastructure and Water management, used the lessons learned in the Sand Engine pilot project in subsequent projects and in new pilots, on both the substantive and process level. The concept of the Sand Engine has also spread across the Dutch borders, to similar projects in the UK, Sweden, Togo and Benin. The different ways knowledge diffused from the Sand Engine to other projects was traced through use of one of the System Dynamics models, the propagation model. The three main ways op propagation recognised are: replication, expansion and routinisation.

As an answer to the research question, this research identified seven factors which, when implemented in policy and new BwN pilots, could improve the use and spread of knowledge from these projects. First of all, the perceived success of the pilot is a prerequisite for significant spread of knowledge, so ensuring the internal success of the pilot is crucial. Other factors are: 2. Including knowledge creation and spread as design factors in the pilot project design, 3. Designing the pilot project to be multi-functional, 4. Ensuring the pilot project fits the long-term policy plans and strategy of important stakeholders, 5. Involving champions of knowledge, who are able to turn over the project at the right time, 6, Implementing knowledge programs within the pilot project and 7. Ensuring the free sharing of knowledge between stakeholders and interested parties.

The scientific relevance and the recommendations of this report for further research include: Performing additional case studies on other BwN pilots for more robust results, expanding the selection of interviewees and changing the way and format in which data is collected, managed and stored in Building with Nature pilot projects to enable the use of this data for simulation models. Through these models, new insights on pilot project propagation can be gained.

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1 Introduction

This chapter will introduce the thesis and the context of concepts like Building with Nature, pilot projects and the Sand Engine project, its suitability as case study for this research and its physical and policy context.

1.1. Dutch coastal erosion

Due to global warming and the associated sea level rise, erosion of the Dutch sandy beaches and dunes has been incrementally increasing in the past centuries. The dunes are an integral part of Dutch coastal defence, protecting the 9 million Dutch citizens and the majority of the dutch economy (65% of GDP) present in coastal areas, of which large parts are below sea level (Stive et al., 2013, Lodder and Slinger, 2022). From the 1700's onward, artificial measures were taken to slow down or negate this coastal degradation, but they were unsuccessful in completely stopping the erosion. Starting in the 1950's, the Dutch government introduced beach and dune sand nourishments, which in turn evolved into shoreface nourishments, the cheaper and lower ecological and societal impact alternative of depositing the sand in front of the coast instead of on the beach itself. These measures were successful, but these nourishments have to be performed every 2 to 3 years to maintain the coastline. Furthermore, the New Delta committee report states that to keep negating sea level rise, the shoreface nourishments would have to go from the current level of 12 Mm^3 of sand per year to 80 Mm^3 each year to maintain the Dutch coast in the high end climate change scenario (Stive et al., 2013, Lodder and Slinger, 2022). In this context, alternatives to these bi-yearly nourishments of increasing size were being explored, while at the same time the philosophy of 'Building with Nature' was gaining popularity.

1.2. Building with Nature

After the 'Watersnoodramp' in 1953, the biggest natural disaster of the 20^{th} century in the Netherlands, measures were taken to ensure a similar disaster and loss of lives would never happen again. These measures included the 'Deltawerken', built to protect vulnerable areas of the Netherlands against the sea. These vulnerable areas are the stretches of Dutch coastline not protected by dunes, which make up about 30% of the total coastline. The Deltawerken are a series of hard, solid concrete storm surge barriers, dikes and locks which shortened the parts of the Dutch coastline not protected by dunes by 620 km and have proven their worth time and time again in the past 70 years (Rijkswaterstaat, 2022a, Rijkswaterstaat, 2022b).

However, these solid coastal defence structures have had a significant impact on ocean and estuary life, by closing off the Haringvliet for example (Airoldi et al., 2005), and have been morphologically disruptive to such an extent, that removing the structures at their end of life cycle becomes almost impossible, like at the Eastern Schelde barrier (Vriend, 2004). Furthermore, these structures become less and less effective over the years, due to an increasing rise in sea level and the degradation of the concrete structures themselves (Stive et al., 2013). Taking these factors into account, this means that using ’hard’ coastal defence structures, like dams and storm surge barriers, may even increase the long term vulnerability of the protected regions instead of reducing it. This could be observed during hurricane Katrina, which destroyed large parts of the coast of the Gulf of Mexico and most notably New Orleans, due to, among other things, the neglect and systematic destruction of the wetlands in favor of the ’hard’ coastal defence, which caused the loss of the natural flood defence these wetlands provide (van Slobbe et al., 2013).

To address these issues and negate them in future projects, a different philosophy on the relationship between nature and engineering projects is slowly being adopted in coastal defence, called ’Building with Nature’. The main principle of Building with Nature (BwN) is: Work with nature, not against it. The official definition of BwN by R.E. Waterman is: *”The flexible integration of land-in-sea and of water-in-the-new-land, making use of materials, and forces & interactions present in nature, taking into account existing and potential nature values, and the bio-geomorphology & geo-hydrology of the coast and seabed”* (2010, p.11).

By placing the forces of nature at the core of the solutions, the BwN projects utilise the relentless power of natural forces, instead viewing them as forces that have to be overcome and subdued, which is a battle that cannot be won over time. To spread awareness about the possibilities of nature based solutions and to create a knowledge base, many BwN pilot projects are being realised, both in the Netherlands and abroad (EcoShape, 2022).

1.3. Pilot Projects

In pilot projects, new techniques, knowledge and approaches are tested in a confined, real world application. In this way, the interaction between the pilot and its context can be observed and this knowledge can be used to improve the project design and demonstrate the real world effectiveness of the approach (Vreugdenhil et al., 2010). It is a tool which takes the step from ideas and studies to the real world application in their intended context. Because of this, pilot projects also have a distinct knowledge gathering objective, to be able to prove the effectiveness of the used techniques or innovations (Vreugdenhil et al., 2010). These characteristics make the pilot approach a good fit for the BwN ideology, because BwN is promoting these new, nature based solutions and techniques of which it is yet to be proven that they will work in their intended context.

1.4. Sand engine

On the intersection of these aforementioned topics, there is the Sand Engine (figure 1.1). The Sand engine is a BwN pilot project, focused on exploring a potentially more sustainable and long term way to maintain the soft and sandy Dutch coast. As explained, the Dutch government used to perform regular sand nourishments at the location of the Sand Engine, which has had a positive effect on the size of the beaches and the strength of the dunes. However, these nourishments were not big enough to negate the effects of sea level rise and the increasing levels of erosion in the long term and had to be repeated at fairly regular intervals (Mulder and Tonnon, 2010).

Additionally, the ecological disruption caused by the yearly sand deposits was significant. So, the Sand Engine was presented as an alternative solution. A pilot project of a single mega-nourishment in front of the Dutch coast at Monster, near The Hague. This hook-shaped, artificial peninsula constructed out of sand would use the energy of the wind and the tides to continuously supply sand along the coast for years to come. In 2011 this pilot project was realised and its results have been promising (de Schipper et al., 2016, Zandmotor, 2021). In the next chapter, the criteria which make the Sand Engine a suitable choice as the subject for the case study in this thesis will be elaborated upon.

1.5. The problem

Similar to the Sand Engine, most, if not all, BwN projects are pilot projects. Pilot projects have the goal of testing out new techniques, innovations or approaches and their viability while promoting learning within the project (Bontje and Slinger, 2017). Because these projects are about learning and proof of concept, it is important to capture, store and analyse all the knowledge that is acquired during the full

Figure 1.1: The Sand Engine. “zandmotor (1200×800)”, 2020 *[Photo]. https://dezandmotor.nl /app/uploads/2020/04/zandmotor.png*

run time of the pilot. With this knowledge, the viability of the project and the techniques used can be justified to public, governmental and private project participants and stakeholders, which can lead to the spread of the ideas and implementation of the BwN building philosophy in other (non-pilot) projects. The successful pilot project itself can scale up in different ways: It can be replicated, so the same type of project of similar scale in a different place. Furthermore, a pilot can also be expanded, so done at a larger scale at the location of the pilot or close to it. It can become routinised, the techniques used become part of the standard way of working, part of the routine process of a project based manner of working. Finally, a pilot project can lead to institutionalisation, where the underlying concept or innovation, the new way of working or doing things, is adopted into policy (Vreugdenhil et al., 2010, Vreugdenhil et al., 2012, Vellinga et al., 2017).

A problem that has arisen is that even successful pilot projects often do not seem to be able to translate their success into scaling up and changes in policy (Breman et al., 2017,Van Buuren et al., 2016). The pilot projects remains a successful one-off and everyone involved returns to their old ways of working. Furthermore, it is often not completely clear which knowledge is acquired by the involved actor network during the BwN pilot projects, who in the actor network of the project have internalised the knowledge and in which other projects this knowledge then gets used. Similarly, the way knowledge originates and spreads through the actor network of the pilot project is not completely known. In short, even successful BwN pilot projects do not seem to reach their goal of changing common practise and policy by providing proof of concept and facilitating learning and the use of new techniques. There seems to be a disconnect or dissonance between the pilot projects and common practise and policy which is tough to bridge. Clearly, knowledge acquired by the actor network in the pilot projects does not easily diffuse through the project borders into the ’real’ world.

1.6. Research Question

Despite this, the Sand Engine is one of the few BwN pilot projects which has managed to not only become relatively well known, but also be replicated in other locations within the Netherlands and abroad. For example, in the Amelander zeegat project in the Netherlands and in projects in England, Sweden, Togo and Benin, the concept of using a large scale sand nourishment dispersed by waves to combat coastal erosion has been implemented, based on the Sand Engine. (Helpdesk-water, 2020,Clipsham et al., 2021, Bontje et al., 2019, Boskalis, 2022). Why does one pilot project seem to take off, but do others seem unable to create change in the way of working of the people involved in the field of work associated with the pilot (Breman et al., 2017)?

To try and answer this question and to be able to advice on which elements to improve or implement in the project design of the BwN pilot projects, two conceptual models will be created. One will be on knowledge creation and spread in a pilot project and the second will be on the propagation of pilot projects. These models will be applied to the Sand Engine pilot project, the case study in this research. The insights provided by this case study application will be used to advice upon improving knowledge spread and increasing the chance of propagation of BwN pilot projects into common practise and policy. This leads to the following main research question for this thesis:

Based on the Sand Engine, how can the use and spread of knowledge acquired in Building with Nature pilot projects be improved?

To answer this question, the first thing that has to be established is the way in which knowledge is acquired by the involved actor network in the Sand Engine pilot. This is a prerequisite for the main research question, because it is crucial to understanding the use and spread of knowledge. If the origin of the knowledge is unknown, it is practically impossible to say anything about the use and the spread of the knowledge because of the lack of context and the missing proof that knowledge was actually acquired from within the pilot project. To be able to say that the knowledge was acquired by the involved actor network, the way in which the knowledge is acquired has to be known.

Furthermore, both the internal use and the spread of the knowledge acquired in the pilot have to be researched. The first part, how the acquired knowledge is used during the Sand engine, will seek to establish how pilot projects get redesigned over their lifetime, through the application of the knowledge that participants gain while working on the project within the project itself. The sharing of knowledge, the second part, represents the internalisation of the knowledge acquired in the pilot project within the involved organisations and their standard ways of working through employees associated with the pilot project and its application in new projects. By understanding these three concepts, the possible improvements to strengthen the use and spread, even beyond the pilot project and involved organisations, can be identified. These four steps together lead to the following four sub-questions:

1. How is knowledge acquired by the involved actor network in the Sand Engine pilot?
2. How is this knowledge used within the Sand Engine pilot?
3. How is knowledge acquired during the Sand Engine pilot spread to organisations and other projects?
4. What improvements can be made to the current methods of knowledge spread and use in Building with Nature projects?

The locations of the answers to these sub-questions can be found in table 1.1

Sub-Question	**Chapter**	**Chapter name**
SQ 1	5	Developing and applying the PIE model
SQ 2	7	Propagating pilot projects
SQ 3	7	Propagating pilot projects
SQ 4	8	Conclusion

Table 1.1: Sub-question answering location

1.7. Structure

In the following chapter, the methods are explained. Chapter 3 describes the literature review, the case study on the Sand Engine is presented in the fourth chapter and in the fifth chapter the pilot individual evolution model is developed and applied to the case study. The sixth chapter presents the validation of the pilot individual evolution model. In chapter seven, the pilot propagation model is explained and applied to Building with Nature pilots. Chapter eight is the conclusion, with the answer to the research questions, the advised improvements to Building with Nature pilots, the limitation of the research and the recommendation for further research.

2

Methods

In this chapter, the methods used to answer the research questions of this thesis and their applicability to the research problem will be described. First of all, the method of the literature review for this thesis will be presented. Secondly, the case study approach will be explained. Then, the applicability of the modelling method used for this research, System Dynamics (SD), to the research problem will be shown and the modelling method itself, along with group model building and the ideology of the two created models, the Pilot Individual Evolution (PIE) and the Propagation (Prop.) model, will be introduced.

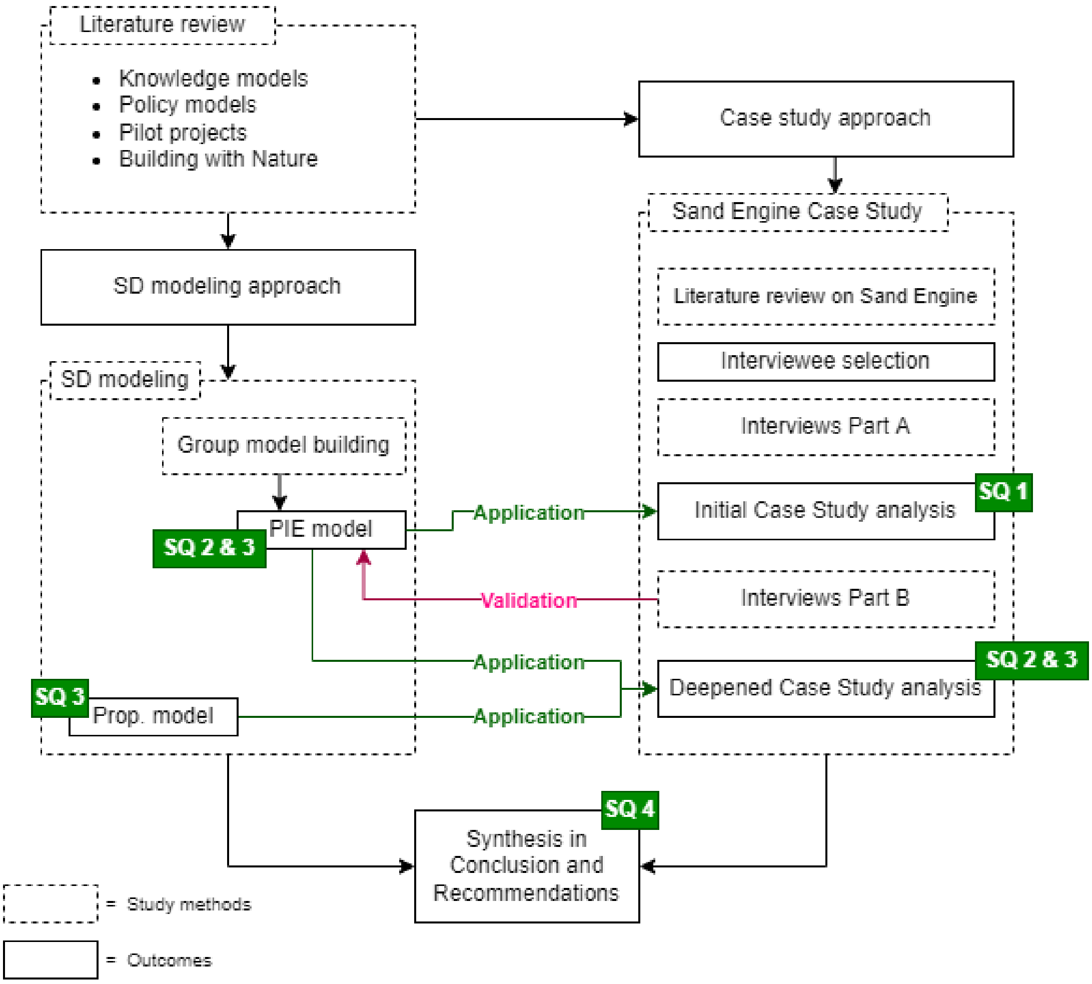

Figure 2.1: Research Structure and Design

Then, the method of interviews and interviewees of this thesis will be explained. Finally, the case study approach and its suitability for the problem at hand will be discussed, along with a substantiation of the suitability of the Sand Engine as the focus for the case study. In Figure 2.1 a comprehensive overview of the research structure and design is presented, with the study methods shown in dashed lines and the outcomes in full lines. The locations of the answers to the sub-questions (SQ) of this thesis are shown in green.

2.1. Literature review

To find out the current state of research on the topics of Building with Nature, pilot projects, knowledge modelling, policy modelling and the Sand Engine, a literature review will be performed. It could be argued that it is more like a knowledge review, because of the fact that the sources are not limited to peer reviewed articles, but for the sake of recognisability and consistency the term literature review will be used. In the report, this literature study will be split up into two parts. The first part is the 'general' literature review, where the existing literature on knowledge models, policy models, pilot projects and BwN will be assessed. This part can be found in chapter 3. In the second part, which is part of the Sand Engine case study, a review of the existing literature on the Sand Engine will be performed. This can be found in chapter 4. Together, these reviews form the knowledge base for the construction of the models, the interview questions and interviewee selection, and the case study.

2.1.1. Search methods and approach

To find the applicable literature, Google Scholar was used as search engine. Search terms included Building with Nature, nature based solutions, Sand Engine, Sand Motor, etc. Through the TU Delft library access to the full papers rather than just abstracts could be obtained. In addition the full repository of grey literature related to the engineering, natural and policy sciences could be searched.

A selection of relevant articles was made to be examined in detail in the literature review. In chapter 3, this selection of literature will be explained, their collective contents will be summarised, and the conclusion on the completeness of literature for the research presented will be drawn using the use and workflow guidelines proposed by Knopf (2006). Knopf states that a literature review is built on four tasks: Determining what each individual study has examined, what the conclusion was of these examinations, providing an overview of these collective conclusions by stating what the literature agrees upon, what it disagrees upon and what it has chosen to ignore. The final task is commenting on the quality and completeness of existing knowledge, what points are researched enough and where could additional research prove to be useful (Knopf, 2006).

The literature will establish that the proposed research question has not been answered yet and show where this research stands in respect to the existing knowledge.

2.2. Case Study

A case study is an empirical research method in which a concept or theory gets analysed by studying a single case intensively, to be able to test concepts in reality (Flyvbjerg, 2011). A characteristic of Case Study research is its linear, but iterative nature (Yin, 2009). Important for the effectiveness of a case study is the selection and scoping of the case, or the 'Casing' (Ragin, 2018). The placement of the boundaries determines the success or failure of the case study. Case studies can also be used to study complex phenomena within their context and provide an opportunity to do research on a concept at relatively low cost in time (Baxter and Jack, 2008).

2.2.1. Suitability of the method

First of all, by singling out one specific case and its context to research, it is possible to go in dept in this specific topic and reach a more thorough answer to the research questions than could have been possible with a broader, but much less intensive, research.

Furthermore, Yin states that case study as a research method is suitable for 'how' and 'why' questions, in a context where the investigator has little control over events and the focus is on a contemporary phenomenon in its real-life context (Yin, 2009). These three factors fit with the thesis and its topic. In this research, the research question itself is a 'how' question and also based on a single case, the Sand Engine. The investigator in this case has no control over events, due to the fact that the construction of the Sand Engine has finished ten years ago and the research is for a master thesis, which is not a part of the Sand Engine project. Finally, the research is on a contemporary phenomenon in its real-life context: A real-life BwN pilot project, The Sand Engine. These factors makes the choice for the case study as a method straightforward and suitable.

To be able to derive results and conclusion from the case study, evidence has to be gathered from multiple different sources. These different forms of evidence have to point to the same conclusion. Yin calls this 'Triangulation' (Yin, 2009). This structure will be followed in this case study, through the triangulation of evidence from the literature review, interviews, and the models which eventually results in the conclusions en recommendations in chapter 8. The suitability of the Sand Engine as the case study subject will be explained in section 2.5.

Alongside the Case Study, System Dynamics modeling is also utilised as a study method (see figure 2.1). In the next section this method and its suitability for this research will be explained.

2.3. Complex, dynamic systems - System Dynamics

To create a representation of the pilot project individual evolution and pilot propagation in models, the modelling method System Dynamics will be utilised in this research.

2.3.1. Origin

System dynamics is a method primarily developed by J.W. Forrester, which came to fruition in 1970 through the book Urban Dynamics (Forrester, 1970). In this book, Forrester used system dynamics modelling to show that building low income housing in an inner city did not alleviate poverty there, but produced it in the long term by taking up space which could have been used to create jobs and by attracting people who need jobs through the low rents. By using system dynamics modelling in relation to management and urban development, Forrester showed that it was a method that could be successfully used for intangible processes like interpersonal relations, attractiveness and character. For example, since these early days System Dynamics has been applied in many fields such as decision making on health systems, managing industrial processes and modelling water systems and their management (Homer and Hirsch, 2006, Akkermans and Dellaert, 2005, Winz et al., 2009).

2.3.2. Characteristics

System Dynamics is a modelling approach for strategy and policy design, which is well suited to aid decision making in complex and dynamics systems. A system can been seen as complex and dynamic due to: The multiplicity of its elements (natural, technical, economic and social) and of their interactions, but also because of the diversity of behaviours and properties it can exhibit (dynamic, emergent, etc.). A complex system is dynamic when characterized by: (1) strong interactions between the various actors of the system, (2) a strong dependency on time, (3) an internal complex causal structure subjected to feedbacks, and (4) delayed behavioural reactions, which are counter-intuitive and difficult to predict (Sterman, 2000, p.5-6).

Furthermore, SD is inherently interdisciplinary. In complex and dynamic systems, there is never a purely technological problem. The societal, political and other impacts of the proposed solution influence its results and thus have to be taken into account in creating the solution. As famously stated by Sir Thomas More in his Utopia from 1516: *"By applying a remedy to one sore, you will provoke another; and that which removes the one ill symptom produces others, whereas the strengthening one part of the body weakens the rest."* (Sterman, 2000, p.2). The message from even back then is clear: no problem is standalone, it is always part of a greater system. This intersects with and represents the holistic nature of SD and 'systems thinking' which stands at the base of it: Everything is connected to everything. There is no way of isolating a problem or or applying a solution which only influences one thing. This 'Systems thinking' views the world as a complex system, which is heavily interconnected (Von Bertalanffy, 1972). Because of these characteristics, SD is very well suited to model the different forms of propagation of pilot projects and the complex system of knowledge in pilot projects and the ways this knowledge spreads within organisations and beyond (Vreugdenhil et al., 2010).

The syntax of SD, with its stock-flows, feedbacks and causal loops, is as follows: Stocks are represented as squares, these stocks can hold objects which are moving through the system. Flows are represented by broad arrows. The objects that move from stock to stock within the system can do so through these directional arrows. Variables are shown as plain text without a box and the directional influences of these variables are shown by thin arrows with either a + sign, which represents a positive relationship, or a - sign, which represents a negative relationship. A positive relationship means that if variable A increases, the variable B, linked with variable A with a positive arrow, increases too. If this relationship was negative, so with a - arrow, variable B would decrease as variable A increases.

2.3.3. Modelling procedure

The system dynamics modeling procedure can be divided into two types, which can complement one another: One, using a step-wise approach to generate a system description from a thorough problem analysis, so as to analyse the system qualitatively. Two, using a quantitative model to simulate the system behaviour and so, provide insight in ways to improve the design of the system and its control rules (Wolstenholme and Coyle, 1983). Both techniques were attempted in this research. Firstly, SD will be used to sketch out and qualitatively analyse the creation, development and spread of knowledge during a pilot project. This model was constructed through group model building and is called the Pilot Individual Evolution (PIE) model in this research. It is used in aiding the answering of sub-questions 1, 2 and 3.

Secondly, attempts were made to create a quantitative SD simulation model to simulate the different forms of propagation of pilot projects, based on the research of (Vreugdenhil et al., 2012). This model is called the Propagation model in this research and aids in the answering of sub-questions 2 and 3. Due to the available data on pilot projects not being on the right level of aggregation, there was no possibility of gaining results by simulating this model. All data on BwN pilot projects were gathered on the level of individual pilots, not on a aggregate level of BwN pilot projects in general. This means that performing simulations for BwN pilots in general to derive results was impossible. This fact is further discussed in chapter 8. The unavailability of data did not mean that the constructed model was useless. In chapter 7, the information gathered from the literature review and the interviews made it possible to trace the paths of propagation individual BwN pilot projects took and derive answers in that way.

2.3.4. Group model building

For the initial creation and conceptualisation of the model, the technique 'Group model building' was utilised. According to Vennix, group model building is a process in which the client is deeply involved in the construction of the model (1996). The model gets constructed during multiple sessions, lead by the head modeller or modeling team (Vennix, 1996).

Group model application - Pilot Individual Evolution model

In this research, the application of group model building was slightly different than the conventional explanation of the term. Because there is no client in this research, the people deeply involved with the construction of the model were the supervisors and I, together forming the core group for the modeling sessions. The first group modeling session for the PIE model took place during a supervisory meeting with Jill Slinger, Heleen Vreugdenhil and I. In this initial meeting we discussed the possible directions the research could take and what variables could play a role in the model.

The second designated group modeling session consisted of Jill Slinger, Heleen Vreugdenhil, Hammond Antwi Sarpong and myself. It was chaired by Jill Slinger and lasted an afternoon. The first step was a warming up, to get familiar with the subject and see if our ideas about what knowledge we were looking for were aligned. We graphed how we thought three types of knowledge evolved during a pilot project over time (Behaviour over time). These three types of knowledge were individual knowledge, group knowledge and institutional knowledge, based on social learning theory (Onencan, 2019). After this introduction, we collectively started drawing out the variables and their connections on a whiteboard resulting in Figure 2.2. Meanwhile, we were discussing the nature of these relations and the suitability of the variables. This session led to the first informal causal map or qualitative model (Hovmand, 2014). The model was recreated in Vensim and sent to all participants to ensure everyone agreed it represented the outcome of the brainstorm session. After this check, the model was improved and sent to the participants again for feedback. In a third, structured, group modelling session with Jill Slinger and I this model was checked and expanded again, leading to the final conceptual model, named the Pilot individual evolution model (PIE), shown in Figure 2.3.

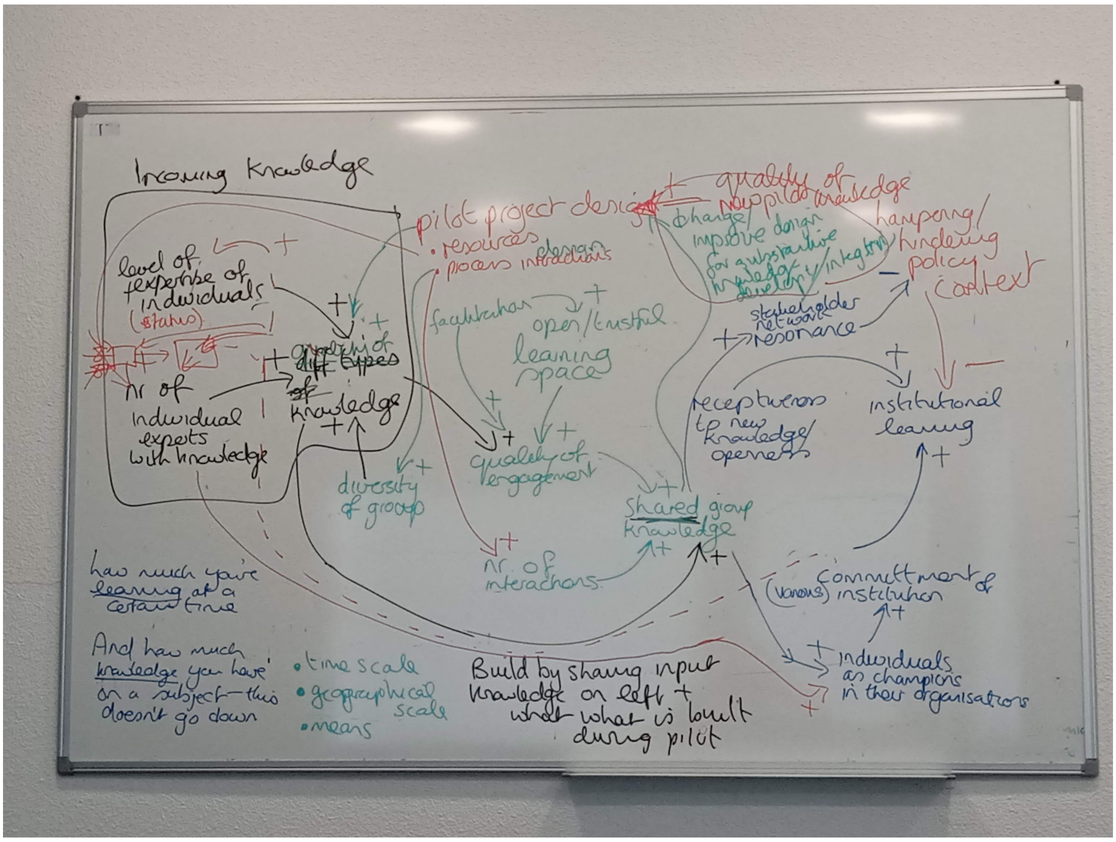

Figure 2.2: The result of the group model building session

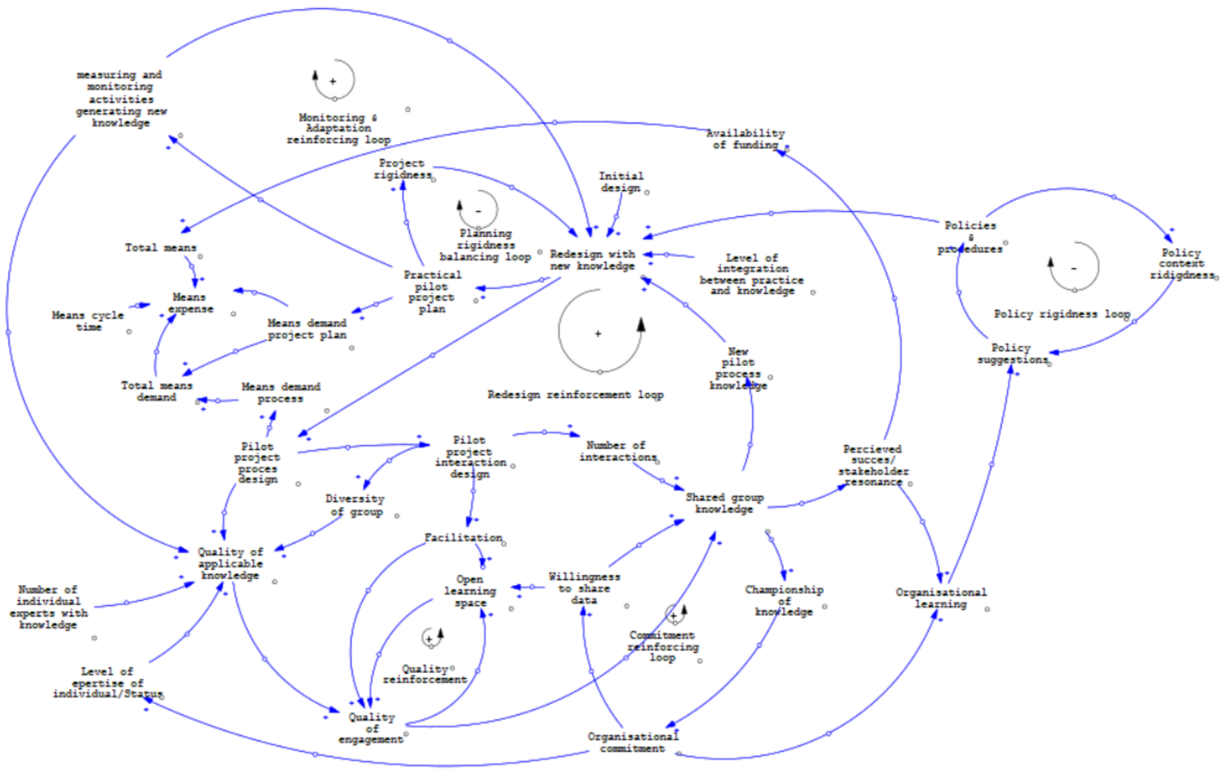

Figure 2.3: The PIE model

2.3.5. Propagation model

The pilot propagation model, shown in Figure 2.4, was based on research done by Vreugdenhil et al. on the different types of 'diffusion' of knowledge that can be observed in pilot projects (Vreugdenhil et al., 2009, Vreugdenhil et al., 2012). There are four types of diffusion of new knowledge and practices from pilot projects. The first way is called *routinisation*. It is the pilot project becoming a integral part of routine project practise. The second way is *replication*, the repeating of the pilot project in a different location with its own unique context, but at roughly the same scale. The third way is called *expansion*. Expansion is scaling the pilot project up around the same location by increasing the size of the project, the duration or both. The last way of diffusion is *institutionalisation*. This way describes the acceptance and internalisation of approach of the pilot project at a higher organisational, sectoral or cross-sectoral level.

For the propagation model, only the first three ways of diffusion will be considered. The diffusion through institutionalisation lies outside the scope of this model, which focuses on the physical spread and propagation of pilot projects and less on the institutionalisation of this knowledge in policy. The model is named propagation and not diffusion, to clarify that it does not address institutionalisation, but the propagation of physical plot projects. However, a form of institutionalisation is present in the PIE model, for completeness.

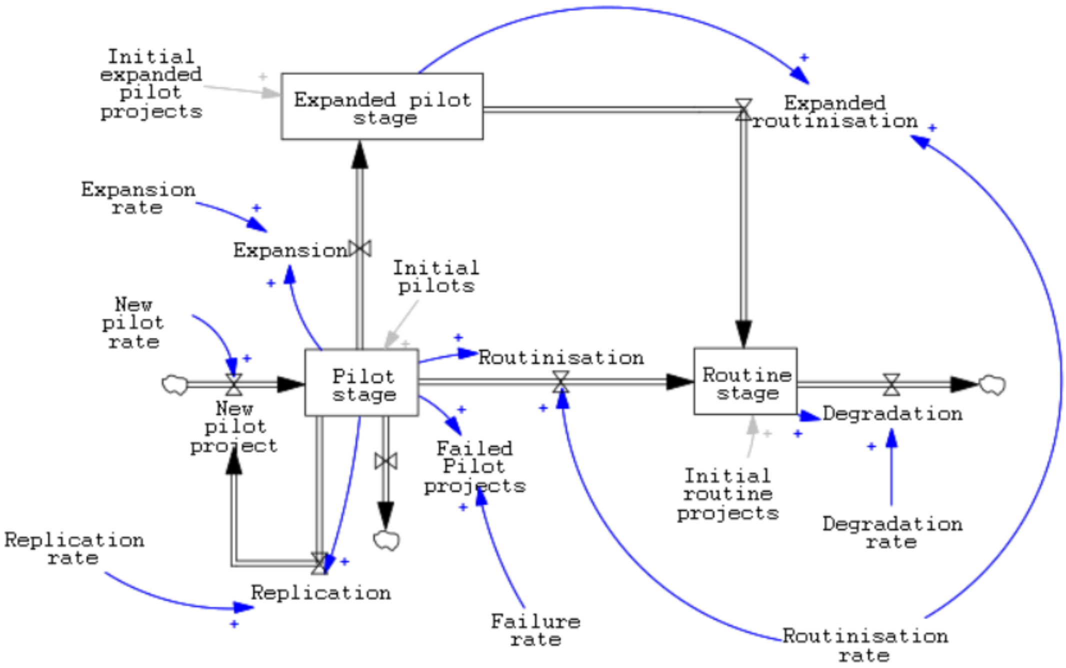

Figure 2.4: The pilot propagation model

2.4. Interviews

To gather more information on the Sand Engine project, to complement the literature review for the case study and to be able to validate the PIE-model, three interviews are performed. These interviews are semi-structured and split in two parts, part A and B. The first part is more open, with general questions about the interviewees occupation and connections to BwN, pilot projects and the Sand Engine. Furthermore, it asks open questions about factors for success in (BwN) pilot projects, examples of successful and unsuccessful pilot projects, the significance of the Sand Engine in the temporal context of Dutch coastal management and more. This part provides context and information for the case study and a deepened understanding of the Sand Engine project as a whole.

The second part, part B, is focused on verifying the PIE model structure, the variables and the connections. The full list of interview questions is in Appendix A and the reports of the interview are found from appendix B onward.

2.4.1. Selection of interviewees

The interviewees were: Q. Lodder, C. van Gelder (both Rijkswaterstaat) and L. Bontje (NatureCoast). They were selected because of their deep familiarity with the Sand Engine project. All interviewees gave their permission for deanonymising the interviews.

Q.J. Lodder works at Rijkswaterstaat (RWS) as coordinating advisor on the water safety of the Dutch coast. He is involved in most of Rijkswaterstaats coastal flood risk management projects. At the time of the construction of the Sand Engine, he was the technical manager for Kustlijnzorg, a program by Rijkswaterstaat tasked with monitoring the Dutch coastal erosion, planning the upcoming sand nourishments and measuring the effectiveness of the performed nourishments. From his work, he has been involved in the Sand Engine project since the very beginning. Furthermore, Kustlijnzorg had a distinct push for innovation, so over the years a lot of different pilot projects were realised, the knowledge of which fits this research well.

C. van Gelder works for Rijkswaterstaat as well, at the section Water traffic and environment in the department of Floodrisk management. She became the program manager for the monitoring and evaluation of the Sand Engine pilot project just after the completion of its construction in 2012. Furthermore, she is program manager of the Zandige kust (Sandy coast) program, which is part of the bigger knowledge program Zeespiegelstijging (Sea level rise). This program aims to improve the current Dutch management and maintenance methods of the coast and adapt it to cope with future sea level rise. She is not only deeply familiar with the Sand Engine, but also with different pilot projects and new innovations tied to Dutch coastal management. This makes her knowledge and expertise a good fit for this research.

L. Bontje was a PhD researcher for NatureCoast, one of the knowledge programs associated with the Sand Engine project. Her research was about the role narratives play in governance of coastal management, the spread of knowledge and stakeholder resonance, based on the Sand Engine. She constructed multiple narratives about the Sand Engine, through open interviews with people involved in the project. These narratives aid in understanding the (perceived) success of the project and how the stories of the Sand Engine create resonance in the involved stakeholder network, which spread the ideas from the Sand Engine further. Due to her research on the Sand Engine and her extensive interviews with the people involved in the project, her expertise sheds a light on the Sand Engine project from a different, but crucial, angle which fits this research very well.

2.5. Applying the case study method to the Sand Engine

For the Case study in this thesis, the suitability of the Sand Engine pilot project has to be explained. This is done in this section. Furthermore, to be able to realise the triangulation to derive reliable insights about the case study, three sources of information and their associated analysis methods were applied to the Sand Engine: Literature review, interviews and System Dynamics models. This triangulation stems from the research on case studies by Yin, mentioned in section 2.2 (Yin, 2009). The case study application is also visualised in figure 2.5.

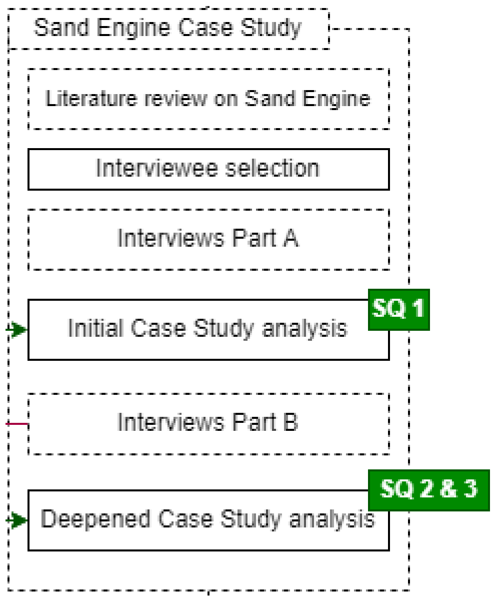

Figure 2.5: Case study application

2.5.1. Suitability of the Sand Engine as case study site

First of all, why is the Sand Engine suitable as the main research object and as the selected case in the case study? Three reasons for why a case could be chosen are identified by Thomas (2021): A personal, intimate connection, it being a very good example of something, and it being different from the norm, an outlier. In addition, Yin identified a criterion for a good case study topic: Access to potential data through interviews, literature of field research (2009). The three reasons identified by Thomas and the criterion by Yin all apply to the Sand Engine in this case, which will be elaborated upon next.

First of all, there is personal affinity and familiarity with the location of the project. Secondly, the Sand Engine is a very successful BwN pilot project. It has reached iconic status and has proven its effectiveness in combating coastal erosion and maintaining the Dutch coast (Bontje and Slinger, 2017). Furthermore, the knowledge acquired in the project and concepts similar to the Sand Engine have spread to multiple different projects within and outside of the Dutch borders (Helpdesk-water, 2020,Clipsham et al., 2021, Bontje et al., 2019, Boskalis, 2022). This shows that the Sand Engine is an exceptional example of an internally as well as externally successful pilot project. Lastly, the Sand Engine is also an outlier in the world of pilot projects, due to its large size, high cost and long timescale. Additionally, it is also an outlier due to its success, as mentioned above. No other BwN pilot projects has reached similar recognisability, spread of concepts and societal acceptance. Finally, there is available information due to its long duration, thorough monitoring and measuring activities and the amount of actors involved. These factors make the Sand Engine a suitable subject for the case study in this research. An explanation of the method application to the Sand Engine case study will follow now.

2.5.2. Literature review

The general literature review in this research can be found in chapter 3, but the literature review for the case study on the Sand Engine is located in chapter 4. Through this review, knowledge is gather which gives insight into the realisation of the Sand Engine pilot project, its significance for Building with Nature and the projects that followed in its footsteps. These results aid in understanding the Sand Engine pilot project, its significance and its diffusion. The case study literature review is done in the same fashion as the general literature review mentioned in section 2.1.

2.5.3. Interviews

The interviews for this case study, of which the template is shown in appendix A, were split into two parts: Part A is a more open interview about the Sand Engine pilot project, its significance in Dutch coastal management, the structure and processes of the project and the crucial factors for its success. Part B is focused on validating the structure, variables and relations of the PIE model, which was made possible by the interviewees deep familiarity with the Sand Engine pilot project, as mentioned above. The knowledge acquired by part A of these interviews is presented in chapter 4, which is then utilised in the development and application of the PIE model in chapter 5. The use of part B of the interviews for the validation of the PIE model is presented in chapter 6.

2.5.4. System Dynamics models

To answer the first three research sub-questions, the conceptual PIE model was constructed through group modeling, literature review and interviews. This model was then applied to the case study: The Sand Engine pilot project. The development of the PIE model, its application to the case study and the results from it are found in chapter 5.

In answering the second and third research question, the initial proposal was to create a quantitative SD model, which would have been simulated with use of the available data gathered by Ecoshape (BwN), TU Delft and Deltares. After construction of the propagation model, shown in Figure 2.4 and explained more in dept in section 2.3.5, based on the research on pilot project diffusion by Vreugdenhil (2010), it became clear that the available data was at a different level then what was needed. The data was on the level of single pilot projects and there was little to no comprehensive and complete data on knowledge created, knowledge spread and pilot diffusion. This made the available data unsuitable for the constructed model. Because of this, the propagation model was used in a more qualitative sense. For the Sand Engine, the different ways in which the project has propagated are traced through the model. The model structure, the tracing of propagation and the conclusions associated with it can be found in chapter 7.

2.6. Connection to Engineering & Policy Analysis

The problem and research questions of this thesis have societal relevance, because BwN as a concept contributes to the reaching of seven of the seventeen United Nations Sustainable Development goals (SDG) (EcoShape, 2022, UN, 2022):

- Clean water and Sanitation.
- Industry, innovation and Infrastructure.
- Sustainable cities and Communities.
- Responsible consumption and Production.
- Climate action.
- Life below water.
- Life on land.

The SDG are an important part of the Engineering and Policy analysis master, often called: 'The Grand Challenges'. This thesis can be linked with multiple of these grand challenges as shown above. Furthermore, in this thesis the Sand Engine system will be taken as a case study and modelled. This model will be built by performing literature research and through interviews with relevant actors. This qualitative model will be utilised to guide the interviews through which the research questions will be answered and relevant (policy) advise can be concluded. Tying in to this, the end result will not be a systems design or a straight up answer, but policy advice for future pilot projects of BwN and other relevant and interested actors.

What makes this research a good fit for Engineering and Policy Analysis and the faculty Technology, Policy and Management in general, is the fact that it focuses on the involved actor network of the pilot projects. It does not solely take the physical aspects or the institutional context of the pilots into account, but researches the effects and the resonance of pilot projects by looking at the involved actors and their networks. This is a good example of multidisciplinary and actor based research. Furthermore, the pilot projects of Building with Nature lie on the interface between public and private domains, which is also the typical domain for the master Engineering and Policy Analysis

The next chapter consists out of the general literature review and its results.

3 Literature review

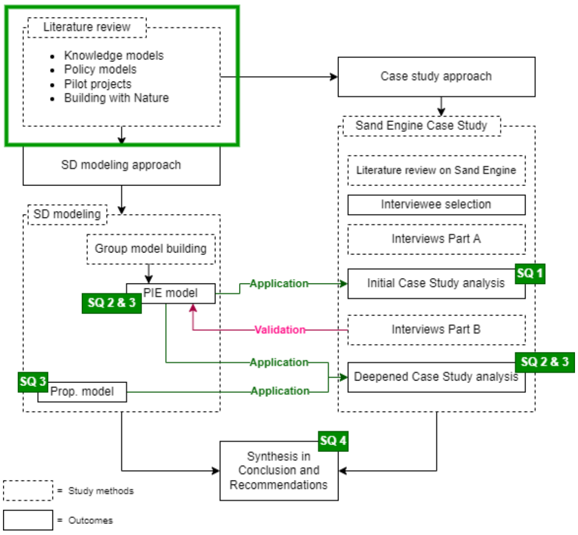

Figure 3.1: Chapter 3 - Literature review

In this chapter, the existing literature on the topics of knowledge and learning, policy models, pilot projects and specifically BwN pilots will be reviewed, an overview of their collective conclusions will be given and the completeness will be commented upon. In chapter 4 the literature review will be expanded to include the Sand Engine as well. The knowledge and conclusions from this chapter will form the basis for the two SD models and the case study.

3.1. Knowledge and Learning

Knowledge and learning come about when different fields and people come together. In this clash, the newly created and implemented knowledge can be seen as emergent behaviour (Kostopoulos et al., 2011). Emergent behaviour is the occurrence of a property or phenomenon that is more complex than the objects which produce it; the whole is more than the sum of parts (de Haan, 2006). Pilot projects are a fruitful base for creating knowledge, because of the multi-actor approach and the focus on facilitating learning (Bontje and Slinger, 2017). This knowledge could prove to be a very useful improvement on common practises in both similar and different fields of work to the pilot project. However, in practise it is very hard for organisations to implement this new knowledge, if it stems from outside of their own organisation (Pfeffer and Sutton, 1999).

There are three different types of learning, individual learning, group learning and institutional learning, based on social learning (Onencan, 2019). Individual learning is the knowledge an individual gains. This can happen through intuiting, but also through the conscious learning processes of attending and experimenting (Castaned and Rios, 2007). Group learning is the knowledge that gets created through interaction between individuals and which gets internalised by them. This interaction and the group learning could come from intuitive interpretation, conversation or could be a form of social modeling (Castaned and Rios, 2007).

Institutional learning is the learning of a institution or organisation. This is the internalisation of knowledge in the ways of working of an organisation or institution. This learning can have the goal of adapting the organisation to their ever-changing environments or even to anticipate these environmental changes (Castaned and Rios, 2007). Additionally, there are four processes which can lead to institutional learning: Intuiting, interpreting, integrating and institutionalising and there are two ways in which it happens: from the individual to the institution (Feed forward) and the other way around (Feedback) (Crossan et al., 1999).

To fully internalise and implement an innovation, Repenning states that, according to the results of his model on knowledge implementation, an organisation needs to commit to an innovation fully to implement it to its full potential. Furthermore, the organisation must not sacrifice the implementation process to force early results (Repenning, 2002). Within the BwN pilots, this could be a reason why the acquired knowledge from pilot projects does not diffuse into common practise (Breman et al., 2017).

3.2. Policy models

There are multiple models which strive to represent the requirements for change in policy and common practice. For example, there is the linear model originated by Lasswell and Lerner (1951) and fine-tuned by Meier et al. (1991). This model states that the policy making process is linear and originates with predictions and prescriptions from the policy practitioners to the policy makers. These policy makers choose the policy and implement it. It ends with the outcome of the policy. There is no feedback or dynamic movement in this representation of the policy process.

To capture the more complex nature of policy making, a model based on several distinct phases was created (J. W. Thomas and Grindle, 1990). This model starts with an issue, which can either be on the agenda or not. This is the agenda phase. If the issue is put on the agenda, it moves on to the decision phase: deciding against or in favor of reform. If the decision made is in favor of reform, the issue and the associated reform move to the last phase, the implementation phase. Here, the policy either gets successfully or unsuccessfully implemented. To conclude, in this model new policy (resolved issue) can either move past each phase towards successful implementation, or it gets derailed and fails in one of the phases.

The last model, which is commonly used, is the three streams model created by Kingdon and Stano (1984). It states that to create a window of opportunity for policy change, three streams have to come together: The Problem, Policy an Politics streams. This coming together does not happen by chance, but is a result of consistent action of people advocating to realise the policy change.

A common denominator in all these models is that policy change stems from perceived issues or problems and that policy does not solely get realised by the policy makers. This perception on policy change can provide some context on why pilot projects do not always seem to reach its desired effect, discussed in the next section.

3.3. Pilot projects

Pilot projects are specific projects designed to test innovations on a small scale in a real world context, without having to live up to expectations placed on full scale projects (Vreugdenhil et al., 2010). The lessons that are learned from pilot projects can be used to improve the underlying concepts of the pilot project and to anticipate difficulties which can arise in a full fledged version of the project. Similarly, pilot projects have a distinct learning objective according to Bontje and Slinger (2017). However, research shows that pilot projects are often seen as effective, but fail to bring significant changes to the established practices which seems contradictory with the learning objective.

The effectiveness of a pilot is the internal success, the significant change in common practise is the external success of a pilot project. Apparently, the internal success of the pilot is no guarantee for external success in common practise. On the contrary even, the conditions that allow pilot projects to be internally successfully are at the same time the conditions that impede the external success of a pilot. This phenomenon is called the 'Pilot Paradox' (Vreugdenhil et al., 2022). These conditions include, among others, the distance to the organisation, the scope and the available means. All the conditions and the pilot paradox are show in Figure 3.2.

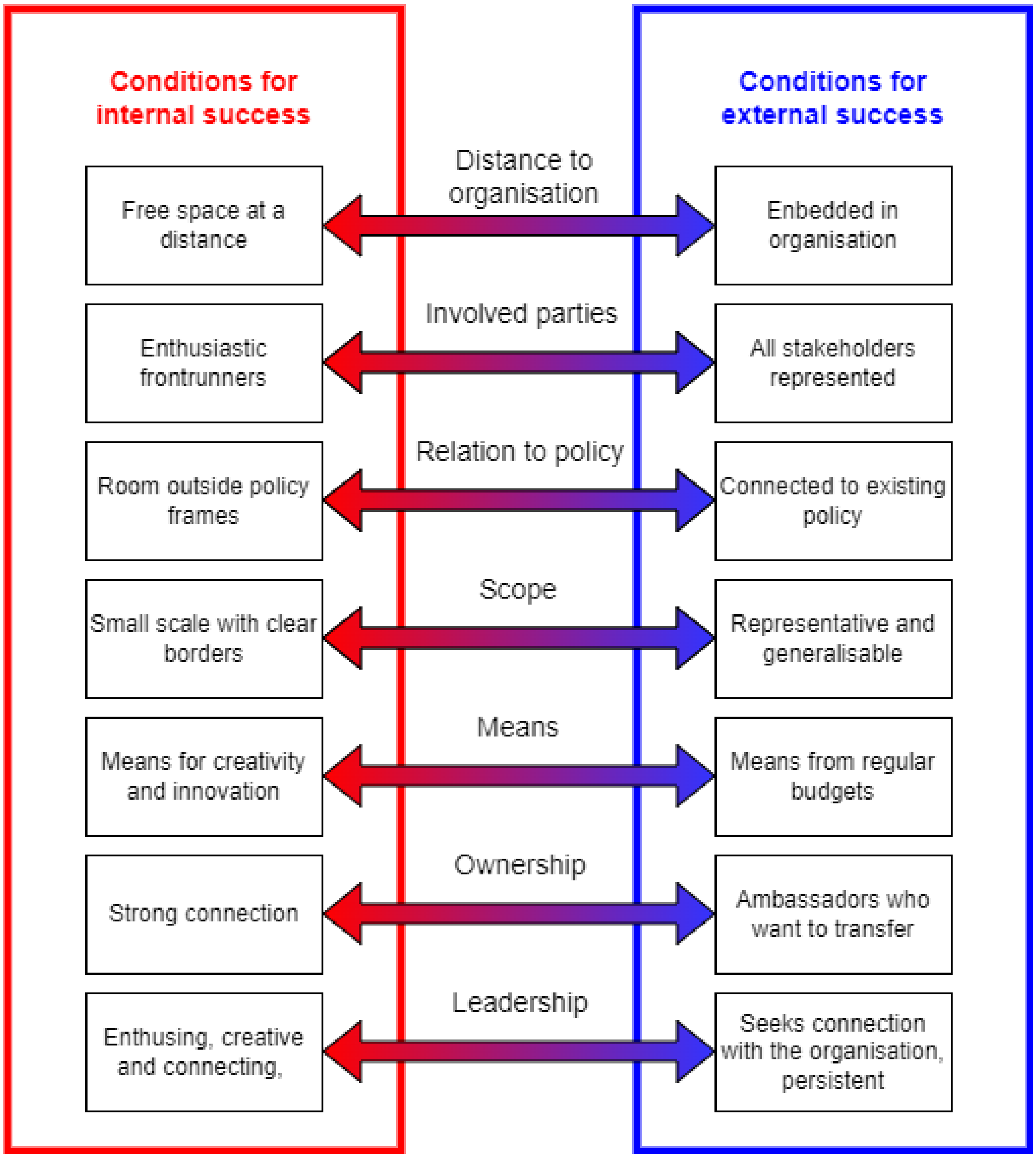

Figure 3.2: The seven conditions for internal and external success. Translated from a figure in (Van Buuren et al., 2022, p.12)

Learning also seems to have tough time crossing pilot project boundaries. It does not seem to easily diffuse from the pilot projects into common practise and other fields of work (Breman et al., 2017). Vreugdenhil et al. analysed the diffusion of knowledge from a pilot project in a case in South Africa, which showed that diffusion mostly takes place within the project itself (2012). There are four distinct ways of diffusion: replication, expansion, routinisation and institutionalisation. To improve the diffusion, to promote the chances of pilot knowledge also spreading to outside of the pilot, action has to be taken early on in the project by making sure that: *"All relevant stakes are represented by their legitimate stakeholders and making enthusiasm initiator independent."* (Vreugdenhil et al., 2012, p.168).

It seems that the step from a pilot project to significant change in common practice is more complicated than just ensuring the internal success of the pilot project. A deliberate effort has to be made from the very beginnings of the pilot project, to get a probability of diffusion of the pilot knowledge. The pilot-paradox seems to be the biggest hurdle, which is why it will be further analysed in the case study on the Sand Engine in the next chapter. The Sand Engine is a Building with Nature pilot project, of which the available literature will be reviewed next.

3.4. Building with Nature pilot projects

The term Building with Nature has been presented in the introduction of this report, along with the suitability of using pilot projects as a method for spreading the ideology. The definition for BwN by its founder, R.E. Waterman, is as follows: *"The flexible integration of land-in-sea and of water-in- the-new-land, making use of materials, and forces & interactions present in nature, taking into account existing and potential nature values, and the bio-geomorphology & geo-hydrology of the coast and seabed"* (Waterman, 2010. p.11). To provide a more tangible overview of what BwN entails, a few of the many BwN pilot projects will be highlighted here (EcoShape, 2022). The most famous project and the topic of the case study in this research, the Sand Engine, will be discussed in the next chapter.

3.4.1. Houtrib dike

The first example of a BwN pilot project is the Houtrib dike, a dike that lies in the Dutch Ijsselmeer and runs from Enkhuizen to Lelytstad (EcoShape, 2018a). To reinforce the dike, traditionally it would have been made higher and broader. At the Houtrib dike, RwS and EcoShape ran a pilot project for the use of a sandy foreshore. A sandy foreshore is a large amount of sand that is placed in front of the dike, which reduces the strength of the waves before it reaches the dike and thus, negating the need to strengthen the dike itself. This pilot project was constructed in 2014 and the monitoring program ran from 2014 until 2018. The project design consisted out of a triangular sand deposit, 400 meters long, 150 meters wide and containing 70000 m^3 of sand, near Trintelhaven. it was constructed at such an angle that the average wave direction was straight towards the waterline.

The goals for the project were applying the technique of sandy foreshores in a lake context and researching its usefulness there. Sandy foreshores are already a proven solution for seashores, but on other locations knowledge and research was lacking. Furthermore, monitoring the ecological developments on the foreshore and their effects on the stability of the sand was also one of the main goals for the pilot. The positive results of the pilot were convincing and in 2019, RwS initiated the construction of sandy foreshores along a large section of the Houtrib dike, consisting of 10 Mm^3 of sand (Rijkswaterstaat, 2020). This can be seen as a clear example of pilot diffusion through expansion, mentioned in chapter 2.3.5 (Vreugdenhil et al., 2012).

3.4.2. Hondsbossche Dunes

In the Dutch province of Noord-Holland, the Hondsbossche and Pettemer sea dikes had to be strengthened because they did not meet the safety standards anymore. Instead of heightening or broadening the dike, as would have been done traditionally, 30 Mm^3 of sand was placed in front of the sea-facing side of the dikes. This project was constructed in 2014 until 2015 and the site were renamed to: the Hondsbossche dunes. The project created a soft, natural barrier between the impact of the waves and the dike, which negated the need to strengthen the dike. Additionally, this sand plane created opportunities for recreation, for studying dune development and had distinct natural values. The monitoring and research program by RwS and EcoShape ran until 2018 (EcoShape, 2018b).

There could be arguments for the fact that the Hondsbossche dunes are not a pilot project anymore, the technology applied was tested at the Sand engine for example and the project is a full scale affair with a distinct goal of improving water safety, with little to no leniency for failure. Then again, what does make it a pilot is the distinct learning objective to research the development of dunes and nature after a large sand nourishment, the optimisation of the design and the way locals and visitors view the project and how their perception evolves (Bontje and Slinger, 2017). The application of lessons learned in the Sand Engine project, by creating a dune lake to promote recreation for example, could indicate a diffusive relationship between the two projects. This standard application of pilot knowledge can be read as a form of routinisation (Vreugdenhil et al., 2012).

3.5. Conclusion

It seems that a driving force behind knowledge and learning is the getting together of the right people. This holds true for policy, pilot projects and BwN as well. Most literature agrees on this fact and furthermore, in different ways they state that, although not easy, the creation of the learning and knowledge is usually not the issue. The spreading of this knowledge and ensuring that the improvements take hold in the organisations is the bigger issue. This phenomenon is described in different papers as diffusion, internalisation, institutionalisation or policy change. They ways in which they are described all differ slightly, but the common theme is that just having a successful pilot of knowledge that is proven to work is often not enough to realise change. There needs to be organisational commitment, a front-runner or champion of knowledge (like EcoShape) and, hardest to realise, the timing has to be right.

In the next chapter the Sand Engine, one of the more prolific BwN pilots, will be studied in a case study setting, starting with an expansion of this literature review to the Sand Engine pilot project.

4

Studying the Sand Engine Case

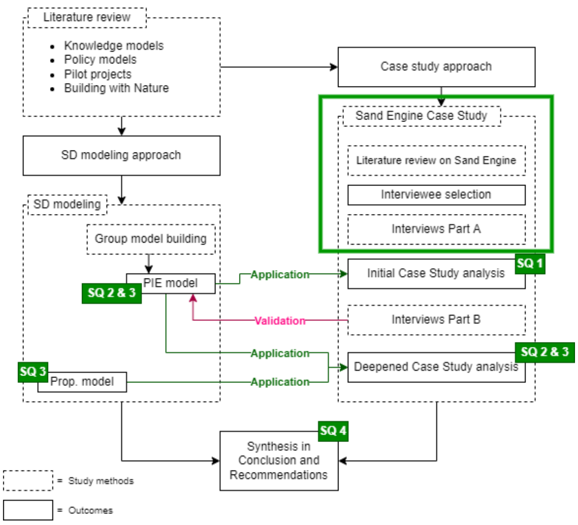

Figure 4.1: Chapter 4 - Case study

In this chapter, a case study with the Sand Engine as subject will be performed. First, the literature study of the previous chapter will be expanded by researching literature on the Sand Engine pilot project. Second, the applicable sections of part A of the interviews will be studied and presented.

4.1. Literature study on the Sand Engine

The most high profile pilot project associated with BwN is the Sand Engine, a hook-shaped peninsula on the Dutch coast near the governmental capital, The Hague. As explained in chapter 1, the Sand Engine is a mega-nourishment, containing 21,5 Mm^3 of sand with the aim of countering anticipated coastal erosion and recession in the following century (Stive et al., 2013, Lodder and Slinger, 2022). To achieve this, natural powers like wind, waves and currents are utilised, which will gradually spread sand across the beaches around the Sand Engine. Realised in 2011, this single mega-nourishment has proven to be more efficient, economical and environmentally friendly than the smaller conventional, yearly, and localised sand nourishments (Zandmotor, 2021). It also created an successful new landscape for nature and recreation (de Schipper et al., 2016).

There are many publications on the the knowledge acquired within this pilot project, particularly on the bio-physical changes caused by the Sand Engine (Luijendijk and Oudenhoven, 2019). Four knowledge programs were associated with the Sand Engine, namely: RwS monitoring, NatureCoast, a Data management program and the Near shore monitoring and modeling (NEMO) program. The RwS program mainly focused on how the Sand Engine was influencing its environment, in a biophysical but also in an governance and ecological way. NatureCoast was very diverse as well, with PhD research ranging from animal life to dune development (Luijendijk and Oudenhoven, 2019).

However, how this knowledge has come to fruition and how it has spread has not been fully researched yet (Bontje and Slinger, 2017). The Sand Engine certainly has inspired comparable projects. For example, knowledge from the Sand Engine pilot has been used in a coastal project in the United Kingdom. A large scale nourishment has been been placed along the beach of Bacton, in Norfolk, United Kingdom (Clipsham et al., 2021). This nourishment was placed there to combat beach and cliff erosion and is, as the project declares, inspired on the concept of the Sand Engine. A similar project is also being realised in the southwest coast of Sweden and along the coast of Togo and Benin (Bontje et al., 2019, Boskalis, 2022).

After the interviews in the next section, the Sand Engine will be analysed through comparison with the pilot paradox (Van Buuren et al., 2016). Why does the project seem unaffected by it and what factors can be found which create these unique circumstances?

4.2. Interviews

From the three interviews performed for this research, the answers and findings of part A will be presented here. The full interviews can be found in the appendix.

First of all, what became clear from all three interviews is that the Sand Engine pilot project can be seen as a success. It reached the goals it was set out to do and the way the concept has spread and how many similar projects have been performed in the years after its completion makes it one of the, if not the most distinct Building with Nature pilot. The key factors for this success were the multi-functionality of the project, the project being in line with the existing Dutch coastal flood and erosion risk management strategy of Rijkswaterstaat, the knowledge programs and the fact that the Sand Engine was a 'stage', on which stakeholders could receive guests and show the projects as a success.

The multi-functionality of the Sand Engine had, according to Van Gelder, ensured that the project even got built when it did. By combining flood protection, recreation, knowledge creation and ecology, a better case could be made for financing the project. If its only function would have been flood protection for example, it would have been too expensive and redundant. Furthermore, the multi-functionality also ensured that every stakeholder in the project could use at least one of these functions to tell a success story about the Sand Engine on a topic that was important to them. Rijkswaterstaat had a new, less intrusive and cheaper way of sand nourishment, the province had a blooming new recreation spot and improved ecology and the knowledge programs had multiple published articles and new knowledge.

All three interviewees mentioned the fact that the Sand Engine pilot project was part of the existing Dutch coastal flood and erosion risk management strategy of Rijkswaterstaat. All types of nourishments built on the previous techniques. It went from beach nourishments, to foreshore nourishments, to gully wall nourishments to finally, the Sand Engine (mega-nourishments). The driving force behind this innovation was the pressure from the Dutch government to become more cost-efficient, to achieve the same or bigger goals for a lower price. Because of this, strategies and methods were already in place long before the Sand Engine to process the knowledge generated in pilot projects and apply it to new pilots down the line. Rijkswaterstaat tried the techniques, kept the aspects of it that worked well and were an improvement and tried to implement these in further projects.

The four knowledge programs in the Sand Engine project were important for the creation, management and documentation of all the knowledge that was acquired during the Sand Engine pilot and were also a big part in the spread of this knowledge. The two main knowledge creating programs were the Rijkswaterstaat monitoring program and the NatureCoast knowledge program. The other two, a database management program and a near shore monitoring and modeling program, played a more complimentary role by providing tools like a data management systems and calibrated models. In the Sand Engine project and in these knowledge programs, data and knowledge were freely being shared with interested parties and there was an open learning space. This exchange of knowledge happened through official meetings and seminars, but also through informal interactions between the stakeholders of the project. The interviewees see this openness as a driving factor for the creation of knowledge, the spread of it within the Sand Engine pilot and outside of it as well.

The fact that the Sand Engine was a 'stage' for the reception of guest by the stakeholders in the project, helped immensely with spreading the success story of the Sand Engine pilot project according to Bontje in her interview. Because the Netherlands is also very sensitive to stories, especially on water-related topics, the stakeholder resonance was very high in the Sand Engine project. In a similar project proposal in Sweden, where there was no stage and a lower sensitivity for stories, these effects did not occur and to project did not take off like the Sand Engine did.

4.2.1. The pilot paradox

Looking at the pilot paradox from the previous section, it is remarkable that the Sand Engine was both such an internal as well as an external success. The seven trade-offs between internal and external success are: distance to organisation, involved parties, relation to policy, scope, means, ownership and leadership (Figure 3.2, Vreugdenhil et al., 2022).

If you consider RwS, along with the province of South-Holland, as the key organisations behind the Sand Engine, the distance between the two is very small. As a project, it was embedded in the long term strategy of Kustlijnzorg and the Dutch coastal flood risk management strategy, as was said in the interviews (Helpdesk-water, 2017). According to the pilot paradox, this embedding would be very hindering to the internal success of the project, but this is clearly not the case for the Sand Engine (Zandmotor, 2021). For the involved parties, the Sand Engine was not being ran by a small group of front-runners. the interviews and literature show that all parties were involved, with big organisations like Rijkswaterstaat and the province of Zuid-Holland. Again, according to the pilot paradox this should have been a condition which would decrease the chance of the pilot project itself succeeding, but in the Sand Engine this is not the case. All interviews and literature state that the Sand Engine is a clear internal success. In its relationship with policy, the Sand Engine project is completely connected to the existing policy. This was made clear through the interviews with Lodder and Van Gelder, who are intimately familiar with the policy of Rijkswaterstaat. Here as well, this fact should have been a hindering factor to internal success according to the pilot paradox, but it has not prevented the project from becoming successful. On the contrary, the interviewees even state that this connection to policy was one of the reasons for the success of the project. Clearly, the Sand Engine was either a unique case which does not suffer from the pilot paradox, or there are other factors for success which are present in the Sand Engine which are not addressed by the pilot paradox. The same goes for the condition scope. The representativeness and generalisability of the Sand Engine, because of its application in its intended environment, should have impeded its internal success, but this is just not the case.

The means and the ownership are the other way around: Lodder stated in his interview that the Sand Engine was initially realised with money from a special grant by the Dutch government to combat the effect of the ’08 financial crisis. According to the pilot paradox, this should have hampered the chances of external success, or spread of the pilot knowledge. But ideas, concepts and knowledge from the Sand Engine have clearly spread to different projects. However, Lodder also stated that eventual, space in the regular budget was found to accommodate the Sand Engine. A possibility is that this combination was perfect: Special budget to initially realise the project and achieve internal success and then room in the regular budget to achieve the external success and spread of the pilot. For ownership and the leadership, it seems something similar has happened. A core group of front-runners strongly connected to the Sand Engine pushed for the realisation of the project and after this realisation, the project was passed to managers who could take the project further. So perhaps, these front runners felt very much connected to the project, but had enough oversight to pass over the project when it was time according to the pilot paradox. A side note here is that the current ambassadors of the Sand Engine, with C. van Gelder as one of the main ones, still seem very connected to the Sand Engine. So possibly, this trade-off is not as black and white as it seems from the pilot paradox.

4.3. Conclusion

By applying the interviews, a literature study and the pilot paradox to the case study, the Sand Engine pilot project, more insight on the project was gained. The Sand Engine does not seem to agree with the pilot paradox. This incongruity could be an interesting topic in further research. In the next chapter the development of the Pilot Individual Evolution model will be explained and it will in turn be applied to the case study topic, the Sand Engine. Together with the insights from this chapter, the first sub-question of this research can be answered.

5

Developing and applying the PIE model

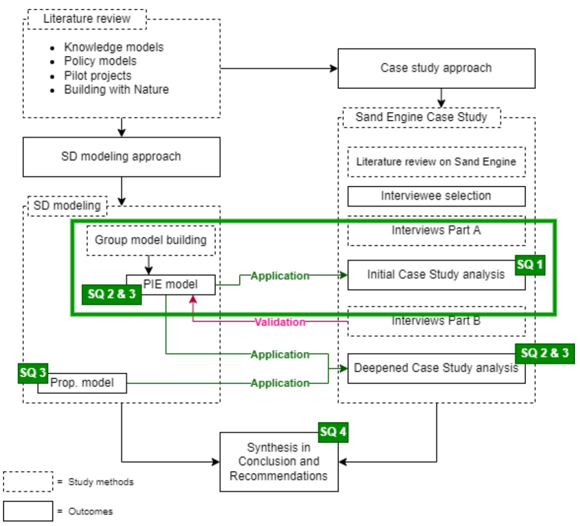

Figure 5.1: Chapter 5 - Developing and applying the PIE model

In this chapter the Pilot Individual Evolution (PIE) model, its variables and its links will be discussed and supported with available literature. The full model is shown in Figure 5.7 at the end of this chapter and it will be cut up for readability and explained part for part in this chapter. The division of these parts was based on if they contained complementary variables and if the parts together strengthened the narrative of the model. The names of variables in the text are presented in italics.

5.1. Model part 1

This explanation of the model will start with the variable '*Initial design*', as shown in Figure 5.2. This variable contains the value for the initial pilot project design. This initial design is used as the base value for the variable '*Redesign with new knowledge*'. Because there is no new knowledge at t=0, the redesign with new knowledge is identical to the initial design and will only start changing when time passes, which will be further elaborated upon later in this chapter. The Redesign influences two variables. First, it influences the *Pilot project process design*. This variable represents the softer side of the pilot project: Who is part of the project, how are they going to be managed, how is the collection, organising and sharing of knowledge going to be structured, etc.

5.1.1. Planning rigidness balancing loop

Secondly, redesign influences the *practical pilot project plan*. This variable entails the physical side of the project; where the sand goes, how its going to be brought there and who is going to do it. The more this is planned out, the less flexible the project becomes. If strict plans are made, changes are harder to implement. This is why an increase in practical planning increases the '*Project Rigidness*' (Brukas et al., 2011). This rigidness, in turn, decreases the redesign with new knowledge because there is less room for change and so, more restrictions on the possible redesign. This relation was endorsed by both Quirijn Lodder and Carola van Gelderen in their interview, of which a full report is present in the appendix. They individually stated that this is a process that happens and increases over time. The steps from redesign to practical pilot project plan, to project rigidness and back to redesign is called the Planning rigidness balancing loop. It is anticipated that this balancing loop will lead to an equilibrium under stable conditions, after an initial period of either growth or decline.

5.1.2. Monitoring & Adaptation reinforcing loop

To facilitate an increase in practical project planning, the project and progress have to be checked through measuring and monitoring activities. To be able to follow the practical plan, you have to measure to ascertain the stage the project at present. Measuring and monitoring provide new data and insights, so a knowledge increase about the progress of the practical side of the pilot project. This is why the practical pilot project plan directly influences the variable '*measuring and monitoring activities generating new knowledge*'. All this newly acquired knowledge can in turn be used to improve the techniques and adjust the project plans, which is why measuring and monitoring feeds back into *redesign with new knowledge* and creates the Monitoring and Adaptation reinforcing loop. Carola van Gelderen recognised this relation from the real world Sand Engine project when asked about it in her interview. Without intervention, this loop could exhibit exponential growth, because these three variables will keep reinforcing each other as explained above.

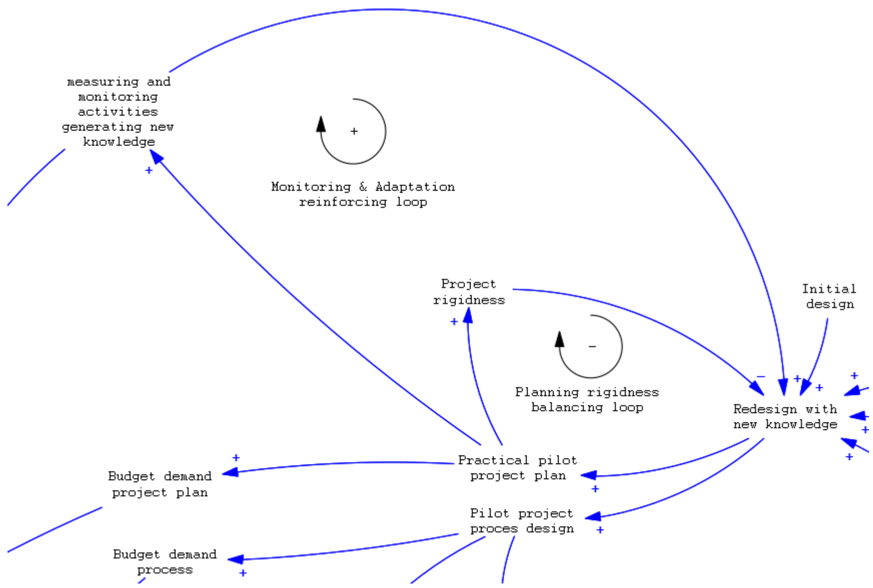

Figure 5.2: Model part 1

5.2. Means

Both the *practical pilot project plan* and the *pilot project process design* require means and thus, have a *budget demand*. This demand increases as the size and complexity of the design increases (Figure 5.3). These two budget demands come together in the *total budget demand*. The *budget expense* is a variable dependent on the *total budget available*, the *total budget demand* and a time factor, called *budget cycle time*. The *budget cycle time* is the time frame over which the budget gets made, which could be monthly, yearly, bi-yearly, etc. For instance, for the Sand Engine, the budget cycle time can be taken as yearly.

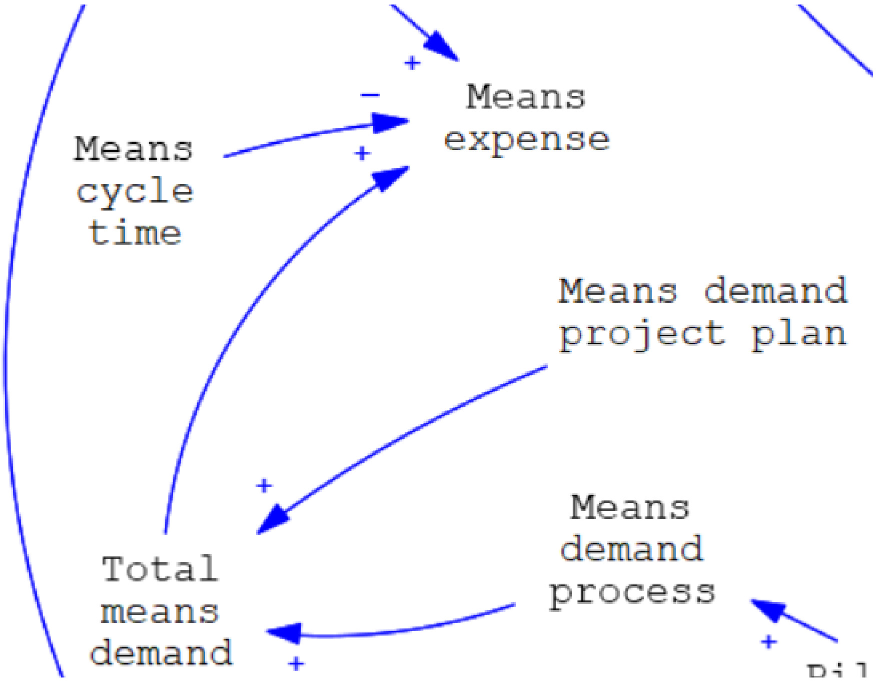

Figure 5.3: Model part 2 - Means

5.3. Engagement

As shown in Figure 5.4, the *pilot process design*, explained in section 1.1, has a direct, positive link to the *Quality of applicable knowledge*. By designing the process with knowledge in mind from the outset, the quality of the applicable knowledge in the pilot will be increased. The knowledge is applicable when it is relevant to the Sand Engine pilot study, in this case.

The *diversity of the group*, the *number of individual experts with knowledge* and the *level of expertise of individual/Status* also influence the *quality of applicable knowledge*. The effect of the first factor, diversity, has been proven to be a positive effect on quality of knowledge (Berliant and Fujita, 2012). The second and third factors, *Number of individual experts* and their *level of expertise* together represent the knowledge that comes into the project through people being sent to work in the pilot project by their organisations and forms an important influence on the quality of applicable knowledge. A few experts with a low level of expertise bring in less quality of knowledge than one or two acknowledged experts in their field can bring. This all depends on the *Organisational commitment*, which is a representation of how much the associated organisations believe in the pilot and how much (human) resources they are willing to invest. A last influence on the *quality of applicable knowledge* is the variable *measuring and monitoring activities generating new knowledge*, explained in section 1.1.

The *Pilot project process design* also has a positive link to the *Pilot project interaction design*, which is a sub part of the process design. It represents the way in which interactions within the project will be organised. How many meetings, who will be there (*Diversity of group*), what will be the context of these meeting, how will they be structured and who will lead them (*Facilitation*)? These are all questions which have a significant impact on how well the interaction in the project will go. Increasing the variable *Facilitation* creates an *open learning space* and increases the overall quality of engagement. Open learning space increases the *quality of engagement* and the *quality of engagement* in turn increases the *open learning space*, creating the Quality reinforcement loop. When participants notice that the quality of the engagement is high, they gain more trust in the process and are willing to put more effort in the engagements, which increases the open learning space. Another variable which increases the open learning space is *Willingness to share data*. If organisations are more willing to share their data, they create an open learning space. This willingness is determined by the *Organisational commitment* of the parties within the pilot project. If a company or organisation is more committed to the pilot project, they are generally more willing to share their data to improve the project.

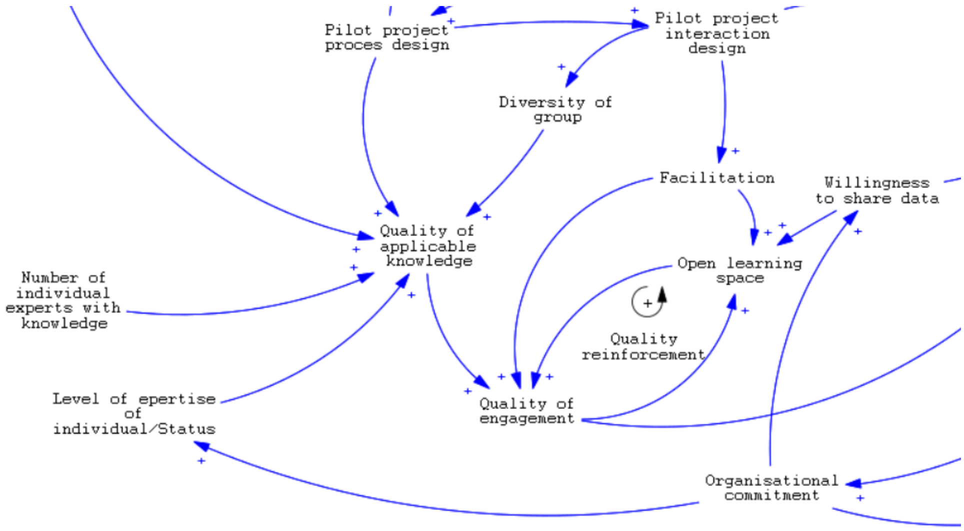

Figure 5.4: Model part 3 - Engagement

5.4. Commitment

There are three variables which increase the *Shared group knowledge* (Figure 5.5). The first two, from the previous section, are the variables *Quality of engagement* and the variable *Willingness to share data* which directly influences the *Shared group knowledge*. The third variable originates at *Pilot project interaction design*, which increases the variable *Number of interactions*, which in turn influences *Shared group knowledge*. If the quality of the engagement and the amount of interactions are high, the amount and quality of knowledge created and shared in the group will increase.

Shared group knowledge is part of the Commitment reinforcement loop. The *championship of knowledge* increases if the *shared group knowledge* increases. *Championship of knowledge* is a variable that represents individuals belief in the created knowledge and their willingness to invest effort to get their organisation/institution to commit to the pilot and to implement the knowledge in their day to day operation. This is why *Organisational commitment* increases when the championship of knowledge does. As explained in section 1.3, *Organisational commitment* increases the *willingness to share data*. The last step that closes the loop is the increase of *willingness to share data* increasing the *shared group knowledge*. This loop also works the other way around: If the shared group knowledge falls, less individuals would take the effort to champion the knowledge, lowering the organisational commitment and in turn the willingness to share data and thus, their contribution to the shared group knowledge.

A rise in *Shared group knowledge* increases the *new pilot process knowledge* and the *perceived success/stakeholder resonance*. This process knowledge can in turn be used in the variable *Redesign with new knowledge* mentioned in section 1.1, which closes the large Reinforcing redesign loop. Together with the *Organisational commitment*, the variable *perceived success/stakeholder resonance* determine the level of *Organisational learning*. How committed the organisation is to the pilot project and the knowledge it creates and how successful it seems to them and other stakeholders is instrumental in how much of the pilot project knowledge becomes institutionalised.

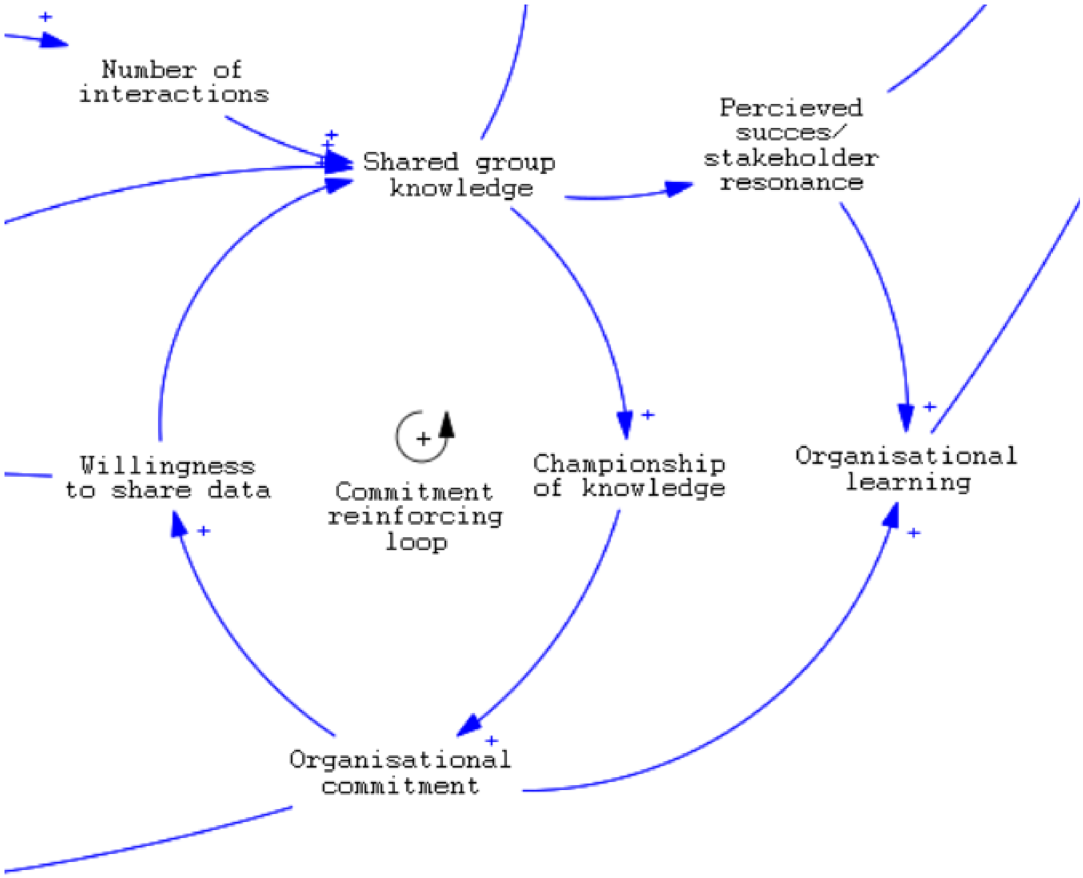

Figure 5.5: Model part 4 - Commitment

5.5. Rigidness

Knowledge internalised in organisations will work its way into *policy suggestions*, which starts the process of the new knowledge becoming common practice in the associated field of work (Epistemological knowledge). Some of these suggestions will become *Policies and Procedures* (Figure 5.6). These *Policies and procedures* have a positive link with the *Redesign with new knowledge* mentioned in section 1.1, because they enable easier implementation of new techniques and knowledge. However, these new policies and procedures increase the *policy context rigidness*, which in turn decreases the room for new policy suggestions. The policy context becomes rigid, because the more 'rules' there are, the harder it becomes to implement new policy without interfering with existing policies. These three variables form the policy rigidness balancing loop, which symbolises the dampening effect of (new) policy and the rigidness of the policy context on the redesign with new knowledge.

What influences the *redesign with new knowledge* as well is the *Level of integration between practice and knowledge*. This represents how well the knowledge gathering and evaluation part of the project interacts with the practical aspects of the project, so for example building or dredging. The stronger this integration, the easier it is to redesign the project with the acquired knowledge, because the practical and knowledge side of the project know and trust each other. Lastly, the *perceived success/stakeholder resonance* increases the support for the project and will in that way increase the *availability of funding*. This will in turn increase the *Total budget* for the project, the variable from section 1.2.
This completes the conceptualisation of knowledge use, sharing and spread in pilot projects undertaken through a series of mini group modelling sessions.

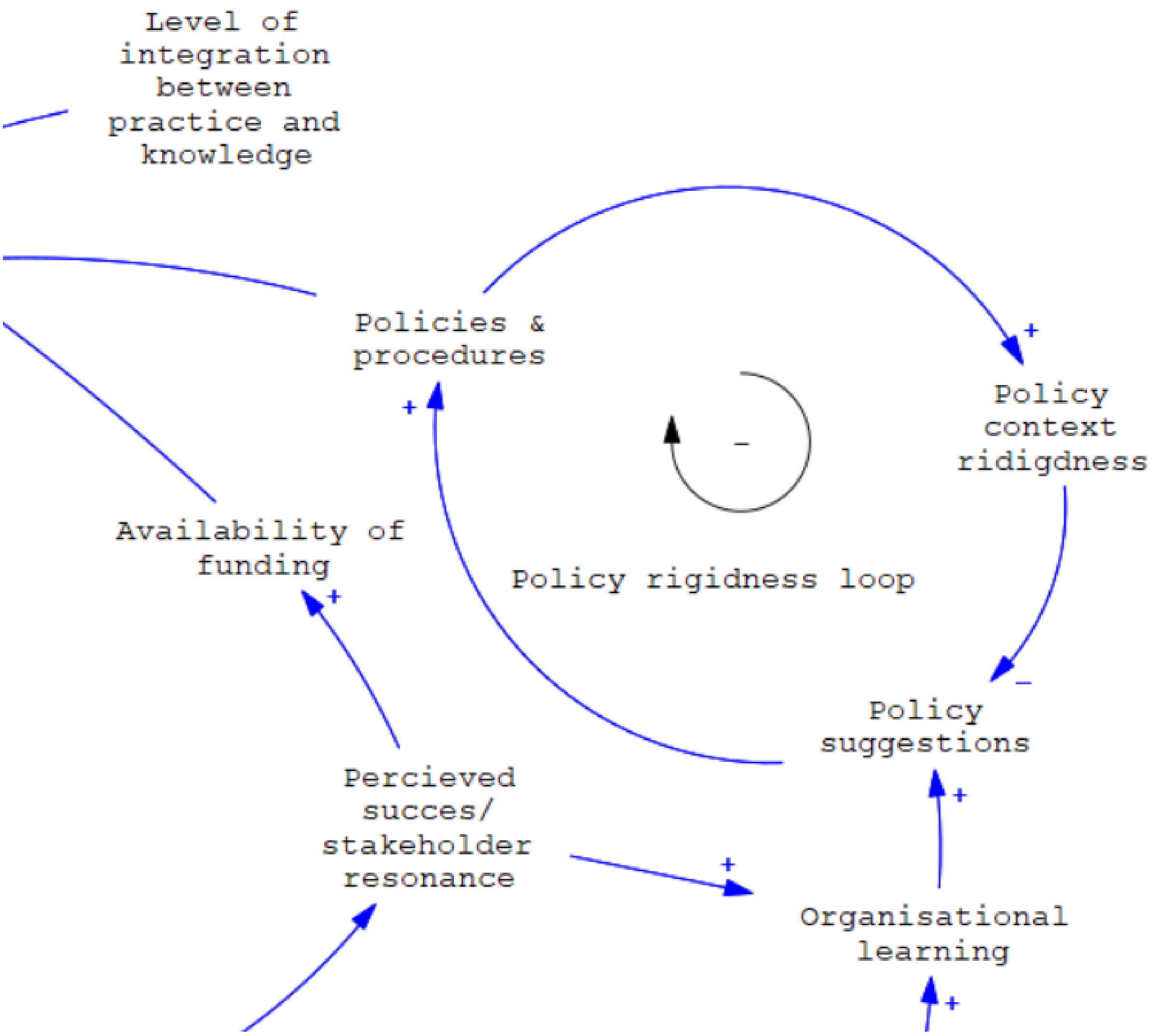

Figure 5.6: Model part 5 - Rigidness

5.6. Application to case study

The results from chapter 4 and this chapter can be combined to the following conclusions. The knowledge acquired in the Sand Engine project by the involved actor network mainly comes from the four knowledge programs which part of the project. These were: The monitoring program by Rijkswaterstaat, NatureCoast, a database management program and a near shore monitoring and modeling program. The interviews made it clear that these first two programs were the main knowledge creators, with the two other programs playing a more auxiliary role of providing insights and tools like a data management system and calibrated models. Additionally, the multi-functionality was a key factor for success for the Sand Engine. From the interviews and the group modeling process behind the PIE model it becomes clear that the free sharing of knowledge and data through an open learning space, meetings and informal interactions between involved stakeholders is a crucial aspect of the Sand Engine pilot project which empowered the creation of knowledge and the quality of the created knowledge. The free sharing of all data with interested parties by Rijkswaterstaat is a good example of this open sharing attitude present in the Sand Engine and the involved stakeholder network.

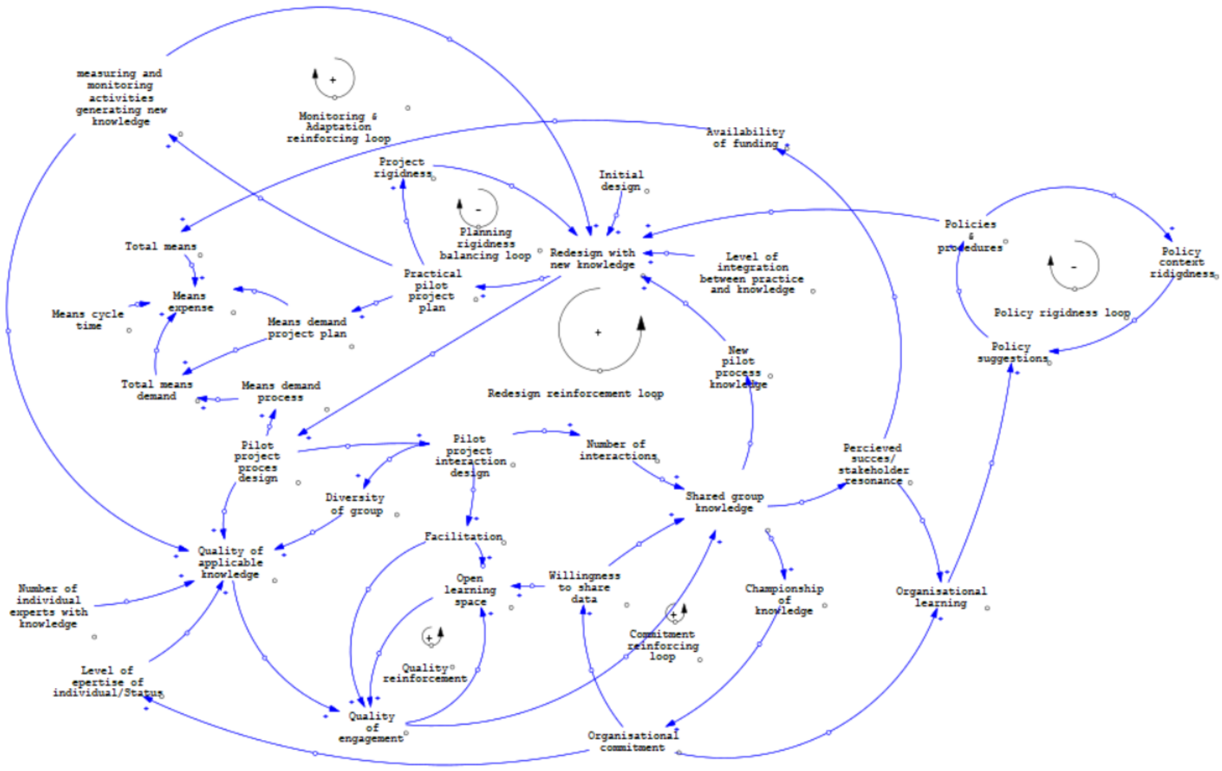

Figure 5.7: Full model

6

Validating the PIE Model

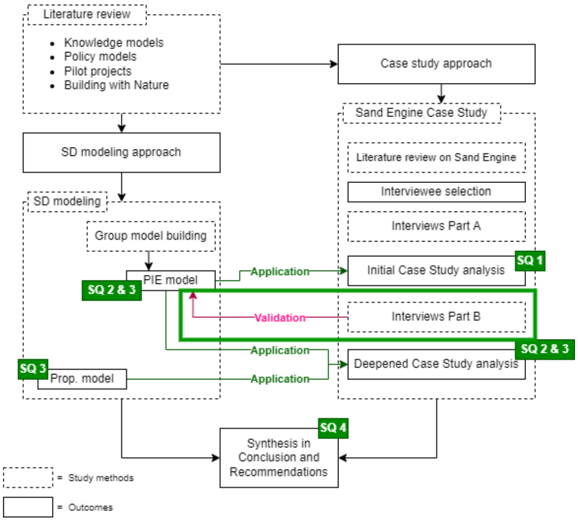

Figure 6.1: Chapter 6 - Validating the PIE Model

In this chapter, the Pilot Individual Evolution model discussed in chapter 5 will be validated through the interviews performed for this report. To validate the PIE model, the links and loops in the model are compared to part B of the interviews that were held with Quirijn Lodder, Carola van Gelder (both Rijkswaterstaat) and Lotte Bontje (previously NatureCoast) about the Sand Engine project compared with the relations in the PIE model. The full interviews are available in the appendix. The model provided a framework for the interviews and in this way, the Sand Engine pilot project will be analysed and the research question can be answered. This chapter will follow the same structure as chapter 5 for ease of reading.

6.1. Model part 1 - Design

The first part of the model, shown in figure 5.2.

6.1.1. Design and trade off between practical and process

For the Sand Engine, the initial design was a result of the inverse tender procedure put out by RwS and the province, according to the interview with Quirijn Lodder. It became clear in that same interview that the practical side of the project and the process/knowledge aspect of it were not competing with each other for limited means within the project, mainly because of this reverse tender procedure. The budget and the amount of sand that had to be added to the system were a set amount and interested parties could create in their designs within these restrictions. Carola van Gelder and Quirijn Lodder also mentioned that the knowledge and process part of the project were separate parts of the project and had their own means, thus not leading to a competition for resources. However, these separate part did interact when it came to sharing knowledge and information, which is visualised in the model through the *Measuring and monitoring reinforcing loop*. A reason for this was the iconic status and the possibility for stakeholders to profile themselves with the Sand Engine project, which meant that all parties were very invested in the project and wanted it to succeed. This made them share information more freely.

6.1.2. Rigidness

For the rigidness loop, the interviewees recognised that choices being made at the practical level of the project resulted in a more rigid project for future alterations. It was mentioned that for the Sand Engine, there was an agreement that after the construction no big alterations would be made to the project, which can be seen as a very rigid choice. However, this was an important part of the pilot character of the Sand Engine, because the involved parties wanted to see what would happen and how the system would react to the mega-nourishment. After time, it also becomes impossible or at least impractical to deviate from the main course set for the project and there is usually not enough time and money available to do both the new idea and follow through with the main line of the pilot. By changing the project halfway, valuable information would be lost and the monitoring programs would have to start from scratch. This was also mentioned in the interviews, that the monitoring programs did suffer form this *planning rigidness balancing loop*. By investing time and money in a certain way of monitoring, a form of path dependence occurred. Maybe the monitoring team discovered a better, different way to monitor a phenomenon but by changing to it, they would lose the continuity of their data and lose progress that way. This is why they often did not change and stayed with the method which they had been using, to avoid throwing away valuable information and provide congruent data.

6.2. Model part 2 - Means

The means section of the model is shown in figure 5.3. This part of the model was different in the Sand Engine project, because the process/knowledge side of the project had its own budget and the practical side had a fixed budget decided upon in the tender.

6.3. Model part 3 - Engagement

The Engagement section of the model is shown in figure 5.4 and contains the process side of the project, the quality of the engagement and organisational commitment.

6.3.1. Quality of knowledge and quality of Engagement

Carola van Gelder recognised the importance of the relevant knowledge of individuals, good facilitation and an open learning space as important factors for the quality of the engagement. Furthermore, she sees it as one of the contributing factors to the success of the Sand Engine. The high level of knowledge from the involved parties, RwS, Universities and knowledge institutes, a very open ambiance in the interactions between stakeholders and facilitation of knowledge creation and sharing through large knowledge meetings twice a year. The openness was enforced through dialogue and RwS being open to criticism and suggestions. The way facilitation contributed to the quality of the engagement was by enforcing the open learning space, but also given structure to the discussions and meetings.

6.3.2. Quality reinforcing loop

This also returns in the quality reinforcing loop. The high quality of knowledge present and the quality of the engagement mentioned above improved the open learing space. In turn, the open learning space made stakeholders part owner of the project and instilled a sense of pride in them. They also agreed that everyone could talk and present about the Sand Engine, as long as they shared their intentions and tried to follow the narrative they established together to avoid surprises. Over time, this created trust between actors and enforced the openness which lead to a higher quality of engagement.

6.4. Model part 4 - Commitment and Success

The commitment part of the model is shown in figure 5.5. This part was more controversial in the interviews, because a case can be made that the links from organisational commitment to shared group knowledge flow the other way around or both ways even.

6.4.1. Commitment reinforcing loop

In the interview with Quirijn Lodder, he did not recognise the fact that championship of knowledge came from inside the pilot project. In his experience, pilot projects only get realised when someone in the organisation acts as the champion or front-runner for the project. This happens when this individual or group of individuals sees the pilot as an opportunity to further their goals or ambitions for a certain policy agenda. In turn, this ensures that the knowledge created within the pilot also finds its way back to the organisation which pioneered the pilot, because this front-runner needs this information to further their policy agenda. Championship of knowledge does not stem from the pilot, it enforces organisational commitment which realises the pilot and enables the creation of Shared group knowledge. There has to be an intrinsic organisational need and pull for the pilot project and its results and knowledge, otherwise the created results do not have the same effect according to Quirijn Lodder.

The view of Carola and Lotte on this relation was more nuanced. Lotte states that the direction of the relationship between the pilot project and the organisational commitment through championship of knowledge is very much dependent on the type of organisation. Some organisations got swept along with the enthusiasm in the Sand Engine project, while others were already intrinsically motivated for it and filled in a more driving role. Like Quirijn, Lotte agrees that Pilot projects need 'drivers', individuals who push for realisation of the pilot project, to come to fruition. However, a lot of knowledge and expertise gets developed within a pilot, of which the involved parties take at least some part back to their organisations. In her view, the relation goes both ways. Carola has seen this relation in the Sand Engine, but mostly in knowledge institutes and universities. In private organisations there is usually less room for this kind of innovation, making it significantly harder to implement knowledge there, even when the willingness from individuals is there. It did happen during the Sand Engine pilot, but was more prominent in the knowledge institutes and universities.

6.4.2. Success, Resonance and Organisational learning

The fact that the perceived success of a pilot influences the amount of internalisation of knowledge from the pilot is underwritten by Carola. She sees the iconic status and (perceived or not) success of the Sand Engine as one of the big contributors to the spread of the ideas from it. So much knowledge was being and was going to be developed in the project, that stakeholders were open to take this knowledge and use it in different contexts. For some parties this was even more in their own interest, because it improved their odds of landing RwS tenders in the future. Carola mentioned the fact that the future plans of RwS are everything but a secret and smart market parties can make themselves very valuable by adapting their methods to the needs of RwS. So the project resonated a lot in the actor network and reached further than even expected. This fits according to Lotte's PhD research, which had an aspect of stakeholder resonance in it as well which fits this relation.

6.5. Model part 5 - Policy and Rigidness

This part of the model is presented in figure 5.6 and visualises the relation of organisational learning to policy creation and the rigidness stemming from this policy creation.

6.5.1. Policy suggestion

Carola mentioned that this step does happen in real life, especially in smaller market parties. This is also underwritten by Lotte, who recognises the relation but is sceptical about the delay between the learning and policy. In her view it depends on the type of organisation as well and the impact of pilot projects could be too small to achieve this effect directly.

6.5.2. Policy Rigidness loop

A big factor is the amount of 'room' an organisation has for new policy and projects. Sometimes there is just no time, money and manpower available to implement a new procedure, even if the idea itself is very good. This could be seen as rigidness, because previously implemented policy and procedures has made the policy context too rigid to allow for new policy suggestions to come to fruition. Carola relates this to the Sand Engine project, that during the pilot ideas were pitched to replicate the project more to the north, in Noord-Holland. These plans were blocked, because the Sand Engine pilot was ongoing and the full extent of information and knowledge about its behaviour was just not available yet. The policy/procedure, building the Sand Engine, made the policy context too rigid for a project similar in size to co-exist with it. However, knowledge stemming from the Sand Engine has been used in different pilots over its life span (Markerwadden, Amelander zeegat, Houtribdijk, etc.), so there is still room for new projects and policy to manoeuvre through this rigidness and reach realisation.

6.6. Full model

The full conceptual model is found in figure 5.7. The interviewees recognised the model construction, the initial design creating the project, the knowledge creation over time through engagement and this knowledge being a reason and push-factor for redesigning the project and decisions made. For RwS, Carola found that is very much represented their way of working: The Plan-Do-Check-Act cycle. A design gets made: Plan, it gets realised: Do, it gets continuously monitored: Check and changes are made accordingly: Act. These cycles take about a year, according to Carola. The guidelines on which the project are checked are not static, they also move with the projects as new information and knowledge becomes available, which also fits the model structure. As for the policy loop, it has increasingly become clear that knowledge and ideas from the Sand Engine have ended up in multiple different projects, like coastal management projects in the Netherlands (Hondsbossche Zeewering, Amelander Zeegat) but also across the border, like in Sweden, Togo and Benin or in England where Sand Engine like concepts are being implemented.

7

Propagating pilot projects

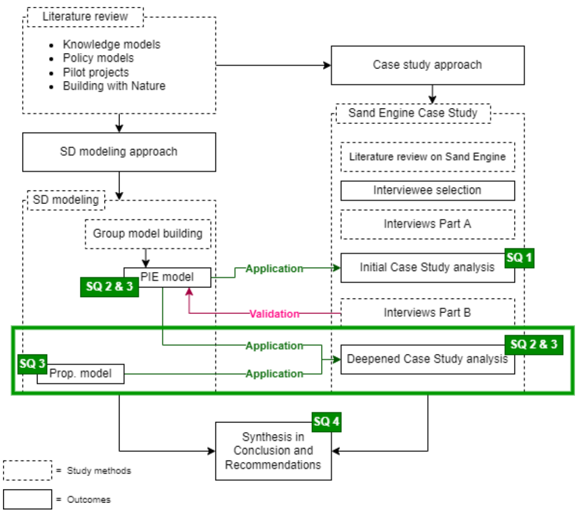

Figure 7.1: Chapter 7 - Propagating pilot projects

In this chapter, the theory of pilot diffusion behind the propagation model and the model itself will be explained. Additionally, different Building with Nature pilots, including the Sand Engine, will be traced through this model to visualise the different forms of diffusion Building with Nature projects can take. Finally, by combining this chapter and the rest of the case study, a conclusion which enables the answering of subquestion two and three is presented.

7.1. Pilot diffusion

The research by Vreugdenhil et al., on the different forms diffusion in pilot projects can take, identified four distinct ones: routinisation, replication, expansion and institutionalisation (2012). Routinisation is the becoming part of routine project practise. Replication is the repetition of the pilot project, but in a different location with its own environment and context. Expansion is a increase in size of the pilot project in roughly the same location. Lastly, institutionalisation is the internalisation of the approach of the pilot project at a higher organisational, sectoral or cross-sectoral level.

For the propagation model, only the first three ways of diffusion will be considered. The diffusion through institutionalisation lies outside of the scope this model and research, which focuses on the physical spread and propagation of pilot projects and less on the institutionalisation of this knowledge in policy or higher organisational levels. This is why the model is called the propagation model and not the diffusion model, to prevent misunderstanding and to clarify that it will not include institutionalisation.

7.2. The model

The full model is shown in figure 7.2. From the left side of the model, *New pilot project* flows into the system. These new pilots accumulate in the stock *Pilot stage*. From here on out, it can take one of four routes. First of all, a pilot can fail. When it fails, no propagation takes places and the pilot leaves the system through the flow *Failed pilot projects*. When a pilot project replicates, it goes through the *Replication* flow and joins the *New pilot project* flow and ends up in the stock *Pilot stage* again. If routinisation takes places, the project flows from the stock *Pilot stage*, through the flow *Routinisation* into the stock *Routine Stage*. Finally, if the pilot project expands it flows from the stock *Pilot stage*, through the flow *Expansion* into the stock *Expanded pilot stage*. From here, the expanded pilot project can routinise as well, through the flow *Expanded routinisation* into the stock *Routine stage*. From the *Routine stage* stock, the routinised projects will slowly degrade over time, because methods get replaced by newer pilots for example.

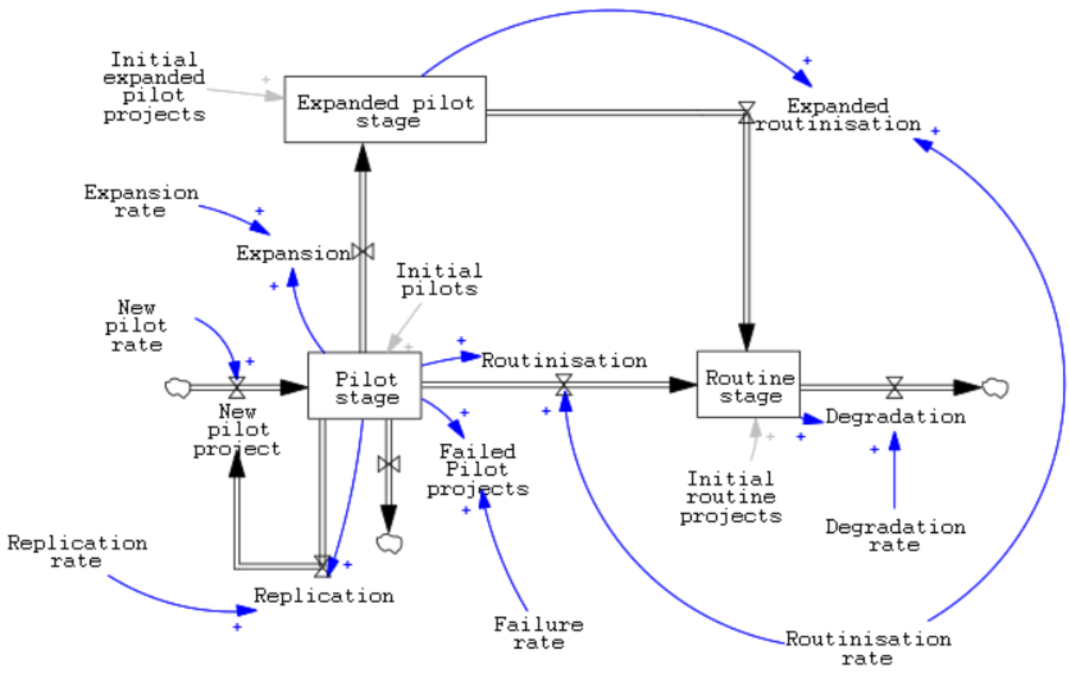

Figure 7.2: The Propagation model

7.3. Propagation

With the propagation model and the information gather from the rest of the case study, different ways the Sand Engine and other Building with Nature pilots have been propagated will be visualised.

7.3.1. Sand Engine

It can be stated that the Sand Engine has become routinised. Leading from the literature review and the interviews, aspects of the Sand engine have become part of the routine project practise of Rijkswaterstaat, for example the value of a lagoon for recreation purposes was realised from the Sand Engine and was in turn implemented in the Hondsbossche dunes project. Furthermore, the idea of a large scale nourishment was reapplied in the ebb tidal delta of the Amelander zeegat project, the use of sand for flood protection was also implemented in the Houtrib dike pilot and at the Marker wadden there was also a distinct integration of knowledge programs like in the Sand Engine. It can be stated that aspects of the Sand Engine have been routinised by Rijkswaterstaat and even other parties abroad, for the projects in the UK, Sweden and Togo and Benin. In Togo and Benin, it can even be said that the Sand Engine is experiencing replication through replication, because these projects are almost a copy of the Sand Engine in the Netherlands (Boskalis, 2022).

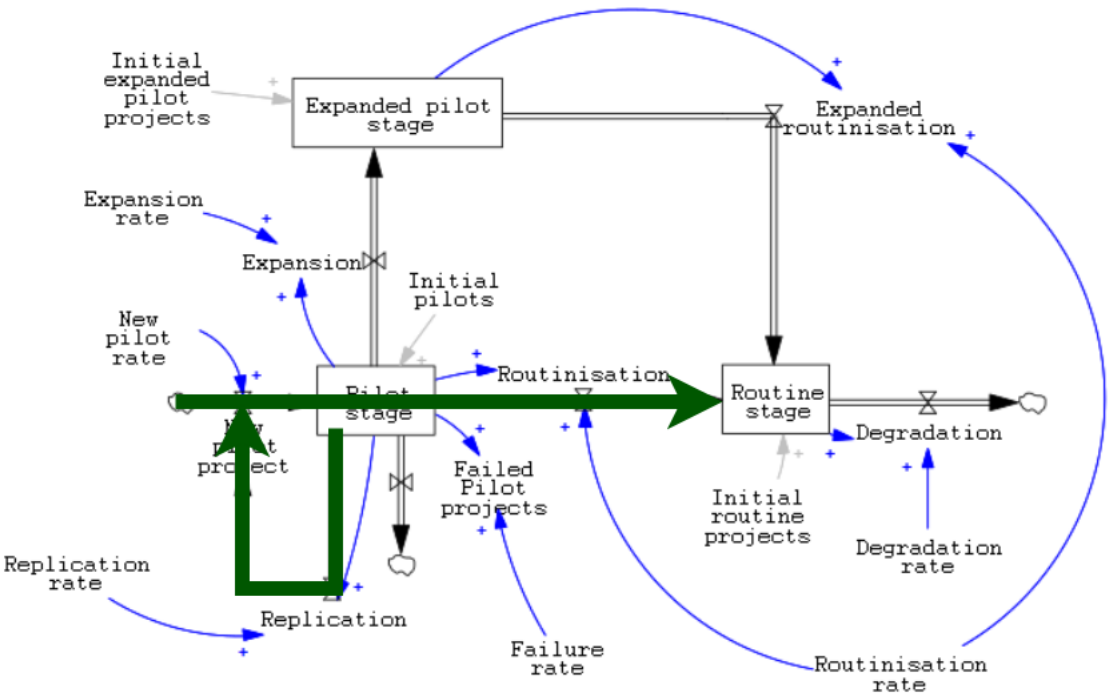

Figure 7.3: Sand Engine Routinisation

7.3.2. Houtrib dike

At the Houtrib dike pilot project, the goal was to apply the technique of sandy foreshores in a lake context and research if it would be useful there. Sandy foreshores are already a proven for seashores (so the re-application at the Houtrib dike can be seen as an indication of routinisation) but for other environments, like lakes, research was missing. The pilot was performed and was successful. In response, Rijkswaterstaat decided to expand the pilot project in 2019 from just a small section of the Houtrib dike, to a full scale project of almost half the length of the dike (Rijkswaterstaat, 2020). This can be seen as a clear case of pilot propagation through expansion.

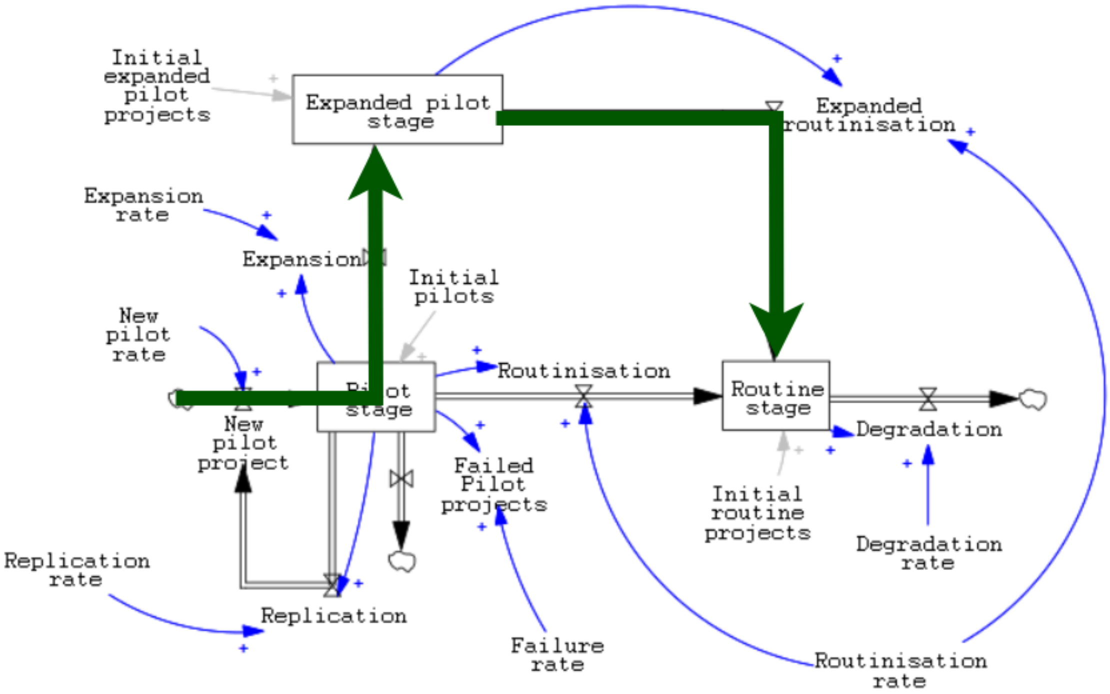

Figure 7.4: Houtrib dike - Expansion

7.4. Conclusion

As a Case Study, the Sand Engine is both a very good example of a Building with Nature pilot and a very clear outlier. The fact that it has been and is successful has become abundantly clear, being one of the most iconic coastal management landmarks in the Netherlands, a figurehead for Building with Nature and a driving force behind newer Building with Nature pilots. From the case study, the PIE and the propagation model and the interviews it can be deducted that its success stems from three factors. First of all, The Sand Engine worked from a coastal Management perspective. It did what is was designed for, negating coastal erosion and strengthening the beaches and dunes around it, without creating dangerous situations for swimmers and other forms of recreation. These forms of recreation were another part of the design, which trumped the expectations in the initial design. From an ecological viewpoint there is also success, with the Sand Engine came a unique habitat which previously did not exist in Zuid-Holland, leading the way for more flora and fauna diversity.

Secondly, A big contributor to its success, both internally and externally, was the fact that the pilot project fit the direction in which the Dutch coastal management by Rijkswaterstaat was moving. It was not a pilot project far removed from any context built to try a random concept. It was a pilot which fitted almost seamlessly in the direction set out 20 years before the realisation of the Sand Engine. There was a need from RwS for the pilot and its results, which was a big contributor to both the internal and external success. RwS was invested in this success.

Lastly, there was the driving force of the other actors involved with the pilot project and the multidimensionality of it. The Sand Engine was a big project, with a very large stakeholder network. A driver of success was the fact that the Sand Engine was designed with multiple functions in mind: Coastal safety, ecology, recreation , economy, etc. Each stakeholder could pick what aspect was important to their organisation and constituency and frame the pilot project in such a way that it highlighted that aspect. Because of these numerous and different narratives resonating in the actor networks, the success story of the Sand Engine spread way further than can be expected of a Dutch coastal pilot project.

8
Conclusion

In this concluding chapter, the research approach is summarised before the main research question is answered by answering each of the sub-questions. This is followed by a discussion of the limitations of the research and recommendations for further work.

For this thesis, the goal was to find out why one Building with Nature pilot project seems to take off, but others seem unable to create change in the ways of working and policy. To achieve this, a case study analysis of the Sand Engine pilot project was conducted, supplemented by a literature review, interviews and the development of two different System Dynamics models. After developing and applying the Pilot Individual Evolution (PIE) model to the Sand Engine case, an initial case study analysis was made through which sub-question one could be answered. Following the validation of the PIE model through interviews and then the re-application to the Sand Engine case, together with the separately developed Propagation model, both sub-questions two and three could be answered. By combining the literature review, modeling, case study results and interview insights, the final sub-question, on the possible improvements that Building with Nature pilot projects could implement to increase their chances of propagation, could be addressed.

For clarity, the main research question and sub-questions are once again presented below:

Based on the Sand Engine, how can the use and spread of knowledge acquired in Building with Nature pilot projects be improved?

1. How is knowledge acquired by the involved actor network in the Sand Engine pilot?
2. How is this knowledge used within the Sand Engine pilot?
3. How is knowledge acquired during the Sand Engine pilot spread to organisations and other projects?
4. What improvements can be made to the current methods of knowledge spread and use in Building with Nature projects?

In the next section, the first sub-question is answered.

8.1. How is knowledge acquired by the involved actor network in the Sand Engine pilot?

There are multiple ways in which the involved actor network acquires knowledge in the Sand Engine project. First of all, there were four knowledge programs being run. A monitoring and knowledge program by Rijkswaterstaat, a knowledge program by NatureCoast, a database management program and a nearshore monitoring and modeling program. From the interviews it became clear that the two programs by Rijkswaterstaat and NatureCoast were the main sources of knowledge, with the other two programs delivering complementary insights and tools like a database management system and calibrated models. The Rijkswaterstaat program collected valuable knowledge on how the Sand Engine was behaving in a morphological and hydrological sense. The NatureCoast program consisted of 12 PhD researchers, with two post-doctoral researchers who tied the findings of the PhD's together. The PhD topics ranged from ecological research to governance analysis. This acquired knowledge was shared with the involved actor network through regular knowledge seminars, meetings and informal exchanges between participants in the Sand Engine pilot project. This relation is underwritten by the Pilot Individual Evolution model and the interviews. For example, the monitoring data gathered by Rijkswaterstaat was freely shared with all interested parties, which exemplifies the open sharing attitude within the project and the involved stakeholder network.

8.2. How is this knowledge used within the Sand Engine pilot?

The knowledge was used in various ways: firstly, the monitoring program itself was also being analysed during the project. When it became clear that some parts of the ecological program were not delivering significant new knowledge compared to its cost, these parts were cut. On the other hand, when it was noticed that kitesurfing was becoming a major recreational and economic factor on the Sand Engine, the monitoring program added it as a factor to maintain and even enforce. So the analysis of the monitoring program worked in two directions.

Second, even though it was agreed that the Sand Engine would be built and after construction nothing major would be changed to ensure that the entire lifetime of the Sand Engine could be monitored, small operational adjustments were made. These adjustments were made to prevent things from going wrong, negating dangerous situations for people swimming or recreating for example. The information needed for these adjustments stemmed from the monitoring and knowledge programs associated with the Sand Engine project, the shared group knowledge, and led to the redesign of specific operational aspects of the pilot project. Furthermore, the knowledge was applied in the numerous meetings and seminars associated with the Sand Engine to build enthusiasm and to affirm the narrative of the Sand Engine as a success. Lastly, the knowledge and data gather during the pilot were used by the PhD researchers from knowledge program NatureCoast, who published multiple papers and spread the knowledge outside the borders of the project.

The Pilot Individual Evolution model represents the internal use of knowledge created in pilot projects. When applied to the Sand Engine case, some aspects of the project are in tandem with the pilot paradox, but some are contradictory to the characteristics that improve the chances for internal success (Vreugdenhil et al., 2022). The means and the ownership in the Sand Engine project are in line with the pilot paradox theory on internal success, while the distance to organisation, involved parties, relation to policy, scope and leadership are contradictory to the conditions for internal success from the pilot paradox. It seems that, on most parts, the Sand Engine is in contradiction with the pilot paradox.

8.3. How is knowledge acquired during the Sand Engine pilot spread to organisations and other projects?

First of all it has to be said that the spread of acquired knowledge would not have taken place if the Sand Engine project had not been successful in what is was set out to do, namely: contribute to coastal flood safety, create new recreational opportunities and benefit the local ecosystem. However, there are other examples of successful Building with Nature pilots which have not achieved this level of knowledge spread, like the Marker wadden. Having said this, the spread of knowledge was achieved in various ways. Mainly, Rijkswaterstaat used a lot of the lessons learned during the Sand Engine project in subsequent coastal flood safety projects. These projects are very much in line with the existing Dutch coastal flood and erosion risk management strategy of Rijkswaterstaat, but the successful ideas and knowledge from the Sand Engine found their way to these projects and were applied there. Projects like Marker wadden, Houtrib dike, Amelander Zeegat and the Hondsbossche dunes all have distinct connections to aspects unique to the Sand Engine. For instance, the use of a large scale single nourishment can be traced from the Sand Engine pilot to the nourishment on the ebb tidal delta of the Amelander Zeegat project. Similarly, the value of the lagoon for recreation at the Sand Engine was also recognised and attempts to add a similar concept to the Hondsbossche Dunes were undertaken. Besides the spread within the Netherlands, the idea of a single large scale nourishments like the Sand

Engine was also spread abroad. Direct descendants are a large scale nourishment along the beach of Baxton in the United Kingdom, a large scale nourishment in the south west of Sweden and a almost direct application of a Sand Engine in projects in Togo and Benin.

Additionaly, process knowledge, on stakeholder management for example, was also spread. In the Sand Engine project, resistance from the local residents lessened after they were involved in the process, told about the goals and ideas of the Sand Engine and felt part of the project. After learning this, Rijkswaterstaat involved the local actors in the Amelander Zeegat project from the out-set, which lead to almost no complaints and a higher degree of understanding from the local residents. Knowledge acquired in the Sand Engine projected therefore changed Rijkswaterstaats way of managing local stakeholders. For the private actors involved in the Sand Engine project, there were also lessons learned and knowledge internalised from the pilot. An example is the adoption of the Data management system used in the Sand Engine pilot project by Witteveen & Bos as their new way of handling similar data.

This way of spreading knowledge acquired in the Sand Engine pilot project was analysed through the propagation model. The way aspects of the Sand Engine and its knowledge propagate to other projects and in turn, how these themselves are propagated, were traced. A key insight here is that the propagation takes characteristics from the initial project and applies it in a different context or environment. For example, the aspects of the Sand Engine that propagated through routinisation to Houtrib Dike pilot is the ideas on flood protection, ecology and a distinct learning objective. However, in the Houtrib dike pilot, this aspect gets applied to a different environment, namely a sweet water lake instead of a sea shore.

8.4. What improvements can be made to the current methods of knowledge spread and use in Building with Nature projects?

It is revealed through analysis of the Sand Engine case study and the Pilot individual evolution model that a main, global answer to this sub-question is that keeping the spread and use of the knowledge acquired in the pilot project as an important design aspect from the very beginning of the project increases this spread and use significantly. Not having a plan for the knowledge and not having systems in place to create it, manage it and spread it is detrimental to the chances of spreading the pilot knowledge outside and even inside the borders of the project. To be more specific, certain important factors for knowledge spreading and pilot success were discovered in this research.

First of all, the pilot project has to be successful in what it set out to do. If the project does not achieve its goals there are lessons learned on why it did not work, but any major spread of knowledge is significantly impaired by lack of success. This is because the success, or even perceived success, is one of the prerequisites for resonance within the stakeholder network. This was identified in research by Bontje (2019). Such resonance, in addition to a success narrative, spreads the acquired knowledge far beyond the directly involved actors and is thus important in the knowledge spread of BwN pilots.

Another important factor for knowledge spread, which was found through analysis of the interviews of this research, is the multi-functionality of the project. Multi-functionality provides a large range of stakeholders with a way to make the project their own and utilise the knowledge and the stories from it to further their own agendas. In this way, the ideas from the pilot get spread way further than would have been possible if it had been mono-functional. An added benefit is the fact that multi-functionality is also helpful in getting the project realised in the first place. From the interviews, it became clear that the Sand Engine project would probably not have existed if it had not been designed with multi-functionality in mind. So, for new BwN pilots, multi-functionality should be a pillar in the initial designs of the projects.

Additionally, designing the pilot to be in line with the associated long term policy agenda and the existing strategy is crucial for the spread of the knowledge and the possibility of scaling up of the pilot. If there is no intrinsic organisational need for the pilot and its results, the chance that the project will get realised and if so, that its results will be internalised and used in new projects, will be small. By analysing the interviews and the way the Sand Engine fit in the timeline of Dutch coastal flood protection, it became clear that the Sand Engine pilot project was in line with the long term policy plans for the Dutch coastal defence. It fit the policy and technical capabilities available at that time, there was a clear plan to use the results and knowledge and Rijkswaterstaat aimed to add mega-nourishments to their so-called 'toolbox'. For future Building with Nature pilots, aligning with the intrinsic needs of the stakeholders and fitting in with the long term policy plans is a fruitful strategy for the spread and use of pilot knowledge.

This intrinsic need can also be created or enforced, through empowering so-called front-runners or champions of knowledge. The interviews made clear that if there are individuals in an organisation who are particularly involved with the location of the pilot or the field in which the pilot would operate, their expertise and efforts can push for the realisation of the pilot and try to ensure that the lessons learned and knowledge created in the pilot will be put to good use in their own organisation. Usually these pilots then fit the long term policy agenda being pushed by this individual, tying in to the previous factor. However, based on the pilot paradox, this front-runner must let the project go at the right moment. Bringing a pilot project to success requires a different skill set (enthusiasm, creativity, linking) than is required for the use, spread and institutionalisation of knowledge (Connection to the organisation, persistence). For new BwN pilots, finding and empowering champions of knowledge can be very helpful in realising the pilot project, but for ensuring the long term application of the knowledge from this pilot this person has to be able to turn the project over at the right time.

Lastly, a factor in the success of knowledge use and spread in pilots is the implementation of knowledge programs in the pilot project and to complement that, a culture of free and open knowledge exchange with interested parties. By implementing knowledge programs in the project, the amount of knowledge and the diversity of it will be increased. This will first of all lead to improvements during the project itself. More monitoring, measuring and research will lead to more insight in the development of the project and provide the opportunity to adapt the project in time to ensure it reaches its goals. A prerequisite for this however, is an open learning space and free knowledge exchange between stakeholders in the project. If the knowledge stemming from the pilots is not shared freely, cues for required changes can be missed because actors miss access to the required information. Furthermore, it can result in a waste of resources, because some actors could need the same information but if it is not shared freely, it would have to be measured or acquired multiple times. So, for new BwN pilots, creating a culture of free knowledge sharing within the project and embedding knowledge programs in the pilot will increase the amount of knowledge acquired, the amount of knowledge used within the project and, because of the increased number of actors involved and the higher quality of the research, it will ensure a better spread of the knowledge throughout the involved actor networks.
If there was more data available on collective success of Building with Nature pilot projects, the timelines from project to project and which distinct aspect of the pilot projects have spread, more insights on the propagation of pilot projects could have been gained.

8.5. Based on the Sand Engine, how can the use and spread of knowledge acquired in Building with Nature pilot projects be improved?

The answer to the main research question is a culmination of all the sub-questions of this thesis and its case study. In the Sand Engine pilot project, knowledge was mainly acquired through the two main knowledge programs in the project, the monitoring program by Rijkswaterstaat and NatureCoast. The free sharing of this knowledge and the open knowledge and data sharing attitude present in the project strengthened the knowledge creation as well. The way knowledge acquired by the involved actor network is used during the pilot is threefold: The monitoring program of the pilot was iteratively adapted throughout its duration to changing circumstances and the acquired data. During the pilot focal points, like kitesurfing, were added and others, like certain ecological programs, were removed. Secondly, the information from the knowledge and monitoring program led to small changes over the course of the project, to ensure the project goals were reached and no dangerous situations for swimmers and recreators would arise. Lastly, knowledge from the Sand Engine project was used by the NatureCoast PhD and post-doc researchers in their publications.

The sharing of this acquired knowledge with other projects was realised in some way by these aforementioned NatureCoast publications. Additionally, the main sharing of pilot knowledge from the Sand Engine can be found in the Rijkswaterstaat sand nourishment projects like Amelander zeegat and Building with Nature pilots like the Marker wadden project. A leading factor in these projects is the fact that the main stakeholders are the same and that these project contributed to Rijkswaterstaats long-term policy plan in which these projects play a distinct role and for which there is an intrinsic organisational need.

The improvements that can be made to the use and sharing of knowledge are diverse. First of all, the internal success of a pilot is the basis on which these improvements rest. If the pilot does not reach the goals it was created for the knowledge from the project can be an example of what not to do, but real spread of the knowledge will be limited due to lack of resonance in the stakeholder network.

Besides that, factors that will increase the use and sharing of knowledge in BwN pilot projects include: Taking knowledge creation, management and spread as important factors from the very beginning of the project and implementing methods and systems for it in the initial design of the project. Having no plan for how to create the knowledge, what to do with the created knowledge, or no way of managing and spreading the created knowledge is detrimental to the chances of spreading any knowledge created in the pilot project.

Additionally, designing the pilot to be multi-functional will not only increase the chances of getting the pilot realised (flood safety, recreation and ecology for the Sand Engine and recreation and nature development for the Marker wadden for example) but also increases the created knowledge and its use and spread. It enables all stakeholders to find parts of the project that fit their goals and create a narrative which reinforces identification with the aims of the project. This in turn will spread the ideas and knowledge of the pilot over a large actor network.

Another factor is to design the pilot in such a way that it fits with the long term policy agenda and existing strategy of stakeholders. This not only creates an intrinsic need from organisations for realising the pilot, but also for the knowledge created in the project. The use, internalisation and spread of the pilot knowledge will increase, if the pilot fits the organisational agenda.

A factor that ties into this intrinsic need is the involvement of champions of knowledge. Individuals who are passionate about the pilot and its possible results, because it fits their policy or goals, will one, help to realise the pilot and two, push for internalisation of the knowledge created by the pilot to further their goals or policy. But, for ensuring the long term application of the knowledge from this pilot, this person has to be able to turn the project over to a individual more suited for long term management and internalisation at the right time. This can improve the use and sharing of knowledge in and from pilot project.

Finally, implementing knowledge programs in the design of the pilot and ensuring a culture of open information and free data sharing will improve the use and sharing of knowledge in BwN pilots. Implementation of knowledge programs will increase the amount and diversity of the knowledge created, which can lead to a larger audience reached and better adjustment of the project to emerging situations. The open culture in turn ensures that there is less waste of resources by performing the same measurements or research twice and that no cues for adjustments to the project design are missed.

All together, these aspects answer the main research question of this thesis. In the next section, the limitations of the research will be discussed and recommendations for further work will be made.

8.6. Limitations

Each research has its limitations. Whether stemming from the chosen system boundaries and scope of the research, or because of the (un)available data and literature on the topic. This thesis is no exception. It is important to address these limitations associated with the study and the choices made in conducting the work.

8.6.1. The case study

The suitability of the Sand Engine as the case study in this research was discussed in chapter 2. However, there are also circumstances that could make the Sand Engine project less suitable or at least color the results in a certain way. Mainly, the fact that the project has become such an icon can be seen as both a good and a bad feature. It is good, because it represents a very successful example of a BwN pilot, from which lessons can be learned for future pilots. On the other hand, this unique success and status could also be the result of a 'perfect storm' of circumstances which are impossible to recreate in a future project design. If that is indeed the case, results and conclusion gathered from research on the project will not translate to projects in different contexts or at least lead to diminished outcomes. However, even though the Sand Engine has most definitely benefited from the fertile project context and right timing, the fact that it forms part of the long term plans of RwS and that specific choices were made to enable knowledge creation and spread lends credence to the the belief that it is still a suitable case study. Alternatives like the Marker Wadden project or the Hondsbossche dunes could have lead to similar outcomes.

The choice for a Case Study as method can also be scrutinised because, as a method, it is not perfectly suitable for aggregating results from the case to the greater family the case belongs to. This criticism is not untrue, but due to the fact that the findings presented in this thesis are mainly related to the initial design of the pilot project. There are certainly adaptations and unique challenges for each project in their unique contexts, but the main recommendations in this research should still apply.

8.6.2. Interviews

In the research for this thesis, three interviews were performed: two with Rijkswaterstaat employees and one with a PhD researcher who did her PhD within the NatureCoast research program. It could be stated that this selection is very RwS focused and small in size. For different and more diverse results, the group of interviewees could have been expanded in number and in diversity, by finding people with different roles and different associations with the Sand Engine and Building with Nature. In this research, their knowledge of the Sand Engine project and relative ease of making contact led to the choice falling on these three interviewees.

8.6.3. Model & Data

For the model, quantification was the initial intention. During the research, it became clear that the PIE model shown in chapter 5 was a qualitative model, which is how it was used in this thesis. The second model, the propagation model, was initially developed as a quantitative simulation model but it became clear the the available data was not on the right level to enable this. Because of this, the model was also used as a qualitative model. A potential limitation also lies in the modeling approach adopted. In this thesis, only System Dynamics was used as the modeling method, but alternative methods such as agent based modeling or discrete event modeling might prove more effective.
In the next section, recommendations will be given for changes to the current collection and level of data, which will enable the propagation model to be simulated as a quantitative model to reach further insights about BwN pilot diffusion and propagation.

8.7. Recommendations

A number of recommendations for future research and changes to the way data is collected for Building with Nature pilots are made: First of all, performing additional case studies on other BwN pilots could provide cross-references for the results of this research. The combination of all these results could yield robust and insightful answers and provide better advice for BwN pilots in the future. Good candidates are the Marker Wadden project and the Hondsbossche dunes.

Additionally, a deepened version of this research could be performed by expanding the selection of interviewees in both number and diversity. This could lead to deeper and different insights on the nature of the Sand Engine and other BwN pilot projects. Possible candidates include local residents, Deltares employees associated with the Sand Engine, governmental officials, province officials and employees of environmental protection agencies or lobby groups.

Furthermore, changing the focus of the data collection from the current individual BwN pilot project focus, to a standardised collective level of focus, could enable the quantification and simulation models like the propagation model developed in this research. First of all, a database or list of all BwN pilot projects should be created, with their respective starting and completion dates. In this way, a timeline for all the pilots can be made through which their propagation can be analysed. Furthermore, information on the characteristics of each pilot has to be collected: What goals are at the base of the pilot (Flood protection, learning and knowledge creation, Ecology, recreation), what aspects are implemented in the design (Mega-nourishment, Lagoons, Sedimentation reuse, Sandy foreshores) and in what type of ecosystem is the pilot being implemented (Seashore, lake shore, river, ebb tidal delta, with the substance being sand, mud, etc.). Together, these data could support queries like: 'Which pilots had a distinct learning objective, while using sand in a lake shore environment in the period between the completion of the Sand Engine and now.' In this way, less obvious diffusion between pilots would be easier to find. The data could be managed in such a way that it could be used in simulation models like the propagation model from this research. In the Figure 8.1 below, a rough draft of such a database could take shape is presented. In addition to this, the model files for the Pilot Individual Evolution and the propagation model are made available for further research and can be received through contacting Jill Slinger, Gerald Jan Ellen or myself.

Pilot project	Dates	Goals	Aspects	Apllication ecosystem	Explanation
Sand Engine	2011-2022	Flood protection, Ecology, Knowledge creation, Recreation	Mega-nourishment, Lagoon	Sand, Sea, Shore, Densly populated, Natural structure	First Mega-nourishment in the Netherlands.
Hondsbossche dunes	2015	Flood protection, Ecology, Knowledge creation, Recreation	Lagoon, Sandy foreshore	Sand, Sea, Shore, Densly populated, Natural structure	Focussed on studying Dune creation, optimising the design and taking visitor experience into account
Marker Wadden	2016-2022	Turbidity reduction, Ecology, Knowledge creation	Sediment reuse, Habitat development	Sediment, Lake, Island, Uninhabited, Man-made structure	Man-made islands constructed out of sediment from the Markermeer
Houtrib dike	2014-2018	Flood protection, Knowledge creation	Sandy foreshore	Sand, Lake, Shore, Man-made structure	A dike reinforcing project using sandy foreshores. It got expanded into a full scale project.

Figure 8.1: Database draft

Lastly, it may be advisable to consider alternative modeling methods such as agent based modeling or discrete event modeling in studying the knowledge acquisition, use and spread within Building with Nature pilot projects.
It is anticipated that by applying these recommendation, learning on implementing Building with Nature through pilot projects will be enhanced. Concepts like Building with Nature offer much needed alternatives to conventional infrastructures and can adapt to the rising sea levels and ongoing climate change.

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A
Interview template

A.1. Introduction (30 min)

I am Guus van den Bosch, a Engineering & policy analysis student at the TU Delft. I am writing my Master thesis at Deltares and the TU Delft, with the subject being on knowledge diffusion from Building with Nature pilot projects. A good and famous example of this is the Sand Engine, which is the subject of my case study in this research. I use System Dynamics as my modeling method to find the causal relations and knowledge flows within the pilots, to be able to analyse what factors are important for knowledge diffusion in pilots and to give advise on adaptation to the projects which would improve this diffusion.

My research question is: Based on the Sand Engine, how can the use and spread of knowledge acquired in Building with Nature pilot projects be improved?

My goals for the interview are twofold. First of all, I want to learn about the context of the creation of the Sand Engine project. How does this project fit in the timeline of Dutch coastal management? Second, I want to validate my model: Do the relations in my model fit with the real project and did I miss things? This second part is a more structured interview, but feel free to interrupt me if you want to.

A.2. Part A

- Could you begin with introducing yourself? Name, function, connection to the Sand Engine, Building with Nature and pilot projects?
- How do you view Building with Nature as a concept?

A.3. Pilot projects

- What are examples of successful pilots and why do you see them as successful?
- What are examples of pilots which did not lead to diffusion of knowledge and techniques?
- What are crucial factors for the success of a pilot?

A.4. Sand Engine

- How do you view the Sand Engine as a concept and as a project?
- How would you place the Sand Engine in the time-context of Dutch coastal management? what came before, what came after?
- What has been the impact of the Sand Engine of knowledge and working methods? Where does it end up? New BwN projects, companies and activities, acceptance and visibility of the BwN concepts

A.5. Part B (30 min)

A.6. Loop 1

In the model there is, because there is a limited amount of time/money/means, a budgetairy trade off in the design of a pilot between practical plans (execution) and process plans (Organisational processes and knowledge documentation etc.). Do you recognise this?
How does it work according to you?
Would you change it? if so, how?
Focus on the practical side of the plans makes the project more rigid and harder to change. Is this so in you experience?
How does it work according to you?
Would you change it? if so, how?
Focus on the practical side of the plans makes it so that more knowledge gets generated by the monitoring activities, which gets used in the redesign of the project. Does it work like that?
How does it work according to you?
Would you change it? if so, how?

A.7. Loop 2

Relevant knowledge of individuals, good facilitation and an open learning environment are important factors for a high quality of interaction within a project.
How does it work according to you?
Are there any factors missing?
Would you change it? if so, how?
A high quality of interaction improves the open learning environment. Do you recognise this?

A.8. Loop 3

The knowledge that gets generated by the group in a project, makes it so that people will push for the project in their own organisations. This increases the commitment of the whole organisation for the project.
How does it work according to you?
Would you change it? if so, how?
The commitment of an organisation and the perceived success of the pilot lead to internalising the pilot knowledge in the organisation.
Do you recognise this?
Are there any prerequisites missing for internalisation?

A.9. Loop 4

The acceptance and internalisation of pilot knowledge in a organisation leads to suggestions for new policy, of which some gets implemented. The more policy there is in a certain area, the more rigid this area becomes and the harder it becomes to add policy.
Do you recognise this?
What would you remove, add?

A.10. Main loop

The pilot desing leads to a trade off between the practical and the process side of the project. The process influences quality of knowledge that gets put together and on the quality of the interactions between participants in the project. This determines the amount and quality of the generated group knowledge. A part of this knowledge gets reapplied to the current pilot, which leads to redesign of the pilot. The internalisation of the group knowledge in the organisation leads to new policy. This new policy is also a factor in the redesign of the project.
Is this true?
How does it work according to you?
What would you add, remove?

A.11. Closing

Did I miss something in this interview what you had expected? Do you have anything to add?

B

Interview Quirijn Lodder

B.1. Could you start by introducing yourself? Name, job description and connection to the Sand engine, Building with nature and Pilot projects?

Quirijn Lodder, works at Rijkswaterstaat (RWS), for the last 20 years. His job is coordinating advisor on water security of the coast. Gives advice to all of RWS on knowledge development in projects and programs and to the ministry on policy. He is involved with the starting of projects: Why are we doing this? Based on what knowledge? Works on the coastal defence of RWS with a big picture view.
Involvement with the Sand Engine: since the beginning. He was the technical manager of Kustlijnzorg and made year reports on the coast called kustlijnkaart. He sees the Sand Engine as a part of the Dutch coastal policy, not at all as a stand-alone pilot outside of the policy context. If it had not been as integrated in the coastal policy as it was, it would not have existed. It is a product of this policy, which aims to let the Dutch coast gradually rise in tandem with the sea level rise (07:10)

B.2. What are examples of successful pilots and why do you see them as successful

There are loads of successful pilots. In 53' there was the watersnoodramp, The Deltawerken were started to shorten the coastline of the Netherlands: Risk control. Around the eighties the Deltawerken were finished, but it became clear that something had to be done about the gradual erosion of the coast. Dynamic enforcement was implemented, with sand nourishments as the measure. First it was beach-nourishments, soon after a few trails with foreshore nourishments as pilots were performed, 1993 Nordtech(?), at Ter Heijde, Scheveningen, etc. In these pilots/trails, the pilot paradox did not exist, or at least Quirijn did not notice them. Crucial for this was that these pilot were a part of the existing strategy. The yearly revision and constant monitoring also helped a lot (Brand, et al. 2022).
All types of nourishments build on one another in technique, volume and in time, see the graph in figure B.1. Each technique gets added into the coastal maintenance 'toolbox'.
Quirijn sees the Dutch coastal defence and the use of the waves to spread the sand, as pre-dating or at least parallel in time to the Building with Nature philosophy. Sand engine would have existed even without BwN, because it is in line with the innovation program of Kustlijnzorg. Kustlijnzorg has a distinct innovation implementation strategy within the program. This is why almost all pilots associated with the program get implemented in the regular way of work or the so called toolbox mentioned above. (18:30)

B.3. Was the implemented drive for innovation in the Kustlijnzorg program deliberate, or more due to circumstance?

It was the intrinsic drive from the program, but it is also built into the mechanisms of the Dutch government. This has to do with cost-efficiency, to realise the sand nourishments on the Dutch coast for the lowest/most efficient price and with the least disruption of the beaches. There was an almost

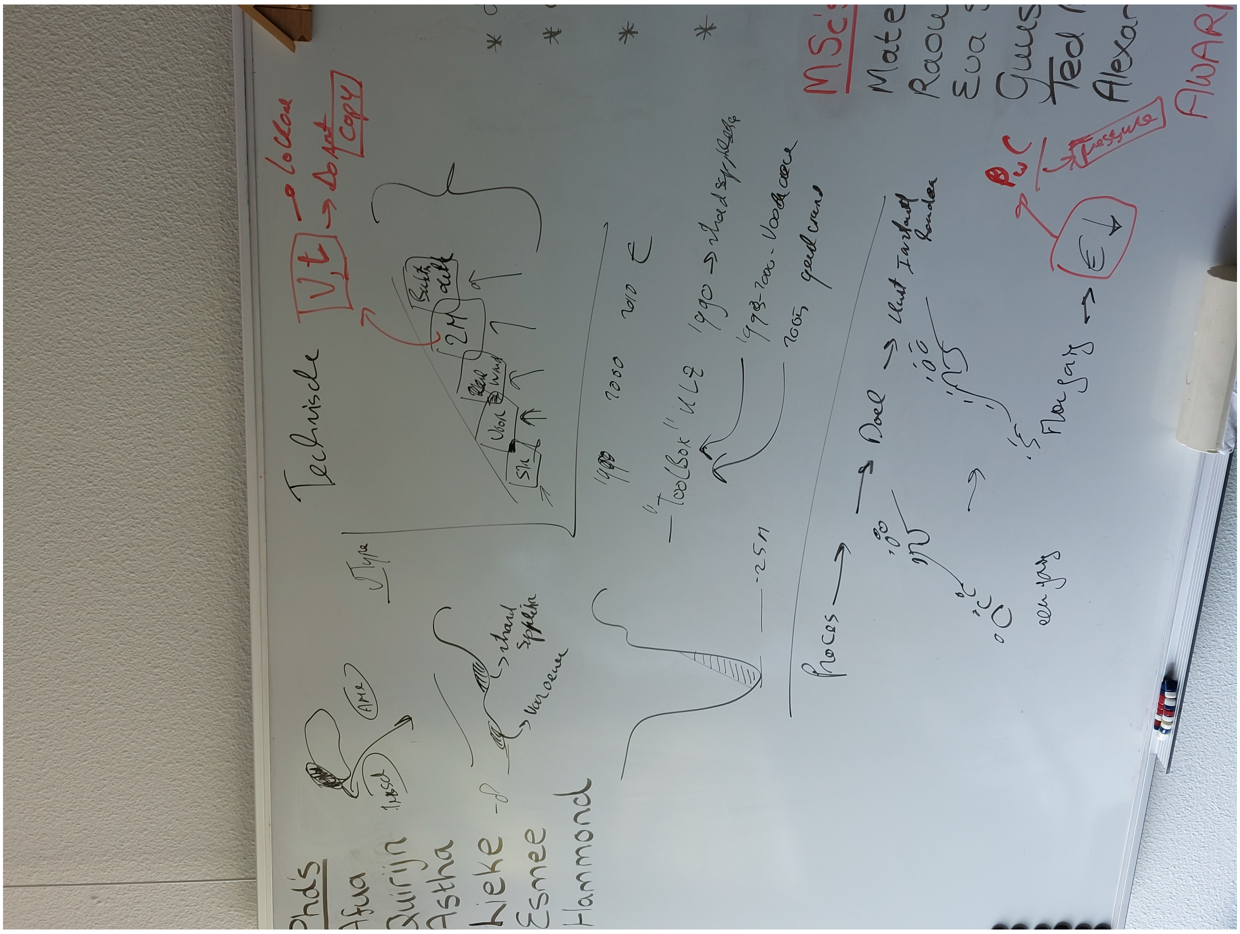

Figure B.1: Drawing Quirijn 1

constant outside pressure to lower the costs, which Quirijn sees as one of the drivers of innovation here. Next to the technical innovations in the styles of nourishments, process innovation took place as well. First, Quirijn and RWS used to make a yearly nourishment program which came full cycle each year. So, evaluating, planning, execution and monitoring for each year. After some years, the acquired knowledge became significant enough to be able to make better predictions and move to multiple year nourishment plans. This led to cost-reductions. To enable this, the knowledge was maintained by a steady core of employees which worked there for longer periods and who passed this knowledge on to the newer workers.
In the analysis, there is a difference between pilots one their own, 'lets try this out', and pilots which are embedded within a program or strategy. The chance for the first type to become externally success is way smaller compared to the second type.
The Sand engine is not going to get a sequel in the form of another Sand Engine being built, but the lessons will get and are being used. The Dutch beaches will have to be continuously heightened, and Sand engine concepts, so larger scale nourishments on a larger timescale, are the preferable option to realise this. The exact implementation depends on local factors.
One important lesson of the Sand Engine is that the natural processes which were expected, did take place. Some slower than expected, like the dunes, so another lesson is that similar processes need time to come to full development.

B.4. Where did knowledge acquired during the Sand Engine end up?

The Sand engine is the most visual, well known example, but working with soft coastal defence has a lot of influence within the Netherlands and beyond. The Dutch have a lot of experience with using soft, sandy solutions instead of hard basalt or concrete ones where possible and this is something which keeps returning according to Quirijn. Like at the Markerwadden, that project would not exist without the successful (soft) coastal maintenance program since the 90's. It is not the same, but the expertise and confidence in the methods is there. (34:00) At the Houtribdijk, a sandy foreshore was created along the dyke to meet the requirements and enable nature development, more so than the original dyke did. Quirijn, and others, see this project as a spin-off or at least as a conceptual successor of the methods used at the coast, like the Sand Engine. The Houtribbijk is an example of expansion. 5 years before the full project, a pilot was performed on a small piece of the Houtribdijk, by Ecoshape, to gather data and provide proof of concept. After the positive results, the rest of the Houtribdijk was strengthened in this way. (37:00) In the individual projects of Room for the River, the work with sediments and the expertise in that field of work could also be seen a successor of the soft coastal projects by RWS. The thinking concepts and the expertise get adapted to the river-context.

B.5. Model questions

(38:50)

B.6. Is there a trade off between the physical project design and the process design in terms of means/time?

Quirijn does not see a direct relation/trade off. More if it fits the goals of the Netherlands as a whole. The Sand Engine fit the current policy, there was previous work (pilots) with mega-nourishments so it followed on that. Crucial for the realisation of the Sand Engine was the credit crisis of 2009 and in reaction, the Dutch crisis and repair law. This was a law meant to boost the Dutch economy by releasing funds to support projects that could be implemented fast and contributed to Dutch innovation knowledge. This investment in the Dutch economy provided budget for the realisation of the Sand Engine. This meant the knowledge was there and the funds were there, so in 1,5 years the necessary studies were done and the project was offered as a inverse tender. The budget was presented and interested parties could send in a mega-nourishment design proposal within certain criteria. Separate from this, the knowledge and monitoring program was developed. So in Quirijns experience, these two processes did not compete for resources, but were separate entities. (46:50) Quirijn was not fully involved with the monitoring, but in his experience, the contractors were very willing to help and work with the process/knowledge side of the sand engine project. Mainly because the Sand Engine was an important project for them, a flagship project very close to The Hague. (49:00)

B.7. Does the monitoring knowledge get reused in the redesign of the project?

The monitoring data got shared with the researchers etc. So Quirijn recognises that loop.

B.8. Does project rigidness increase with an increase in planning?

He recognises this. At the beginning of a project there are more 'freedom degrees'. Along the way choices are being made and with each choice, the amount of options in the future decreases. After a couple of years in a project, if you notice something new, it is often impossible/impractical to change the project to follow it because it deviates from the main line set for the project and there is no time or budget available to do both. Over time and with each choice, this freedom to choose decreases.

B.9. Does a lot of shared group knowledge create champions of knowledge, who return to their organisation and increase the organisational commitment?

You need a front-runner, someone who is willing to push the pilot project and make it a reality. In the Sand Engine, there were a couple of people who were crucial in making it happen. But importantly, Quirijn mostly sees it the other way around than presented in the question. So you need championship of knowledge to realise organisational commitment, which leads to the pilot being realised. The pilot does not create championship of knowledge, the front-runners create the pilot. According to Quirijn, the idea comes first. By holding on to it and pushing for it to become reality/policy, pilots are created. Pilots are means, not ends. As shown in figure B.2, there is a policy line over time, which is being pushed by a certain key drivers: 'champions of knowledge'. This person pushes for pilots and, importantly, also 'pulls' the knowledge created by the pilot to further the policies agenda. One example, a RWS colleague of Quirijn works on the Oosterschelde. He is very attached to it and has done a lot of research on it. He pushes for iterative pilot projects in the area and uses the results to push and support his policy plans to save and maintain the area. He is the champion of knowledge and realises the pilots, the pilots do not realise the champion of knowledge. Pilots who have a driver from within the organisation and which are part of a continuous policy line are the ones that become successful, the pilots which are too far from the continuous policy line or get pushed while they do not fit this line, do not have the same effect. The people working on the continuous policy line must want the pilot and/or its results, otherwise no one will use it.
Die push-pull verhouding werkt, omdat ze ook de mensen zijn die het moeten uitvoeren: Kindon: drie stromen model

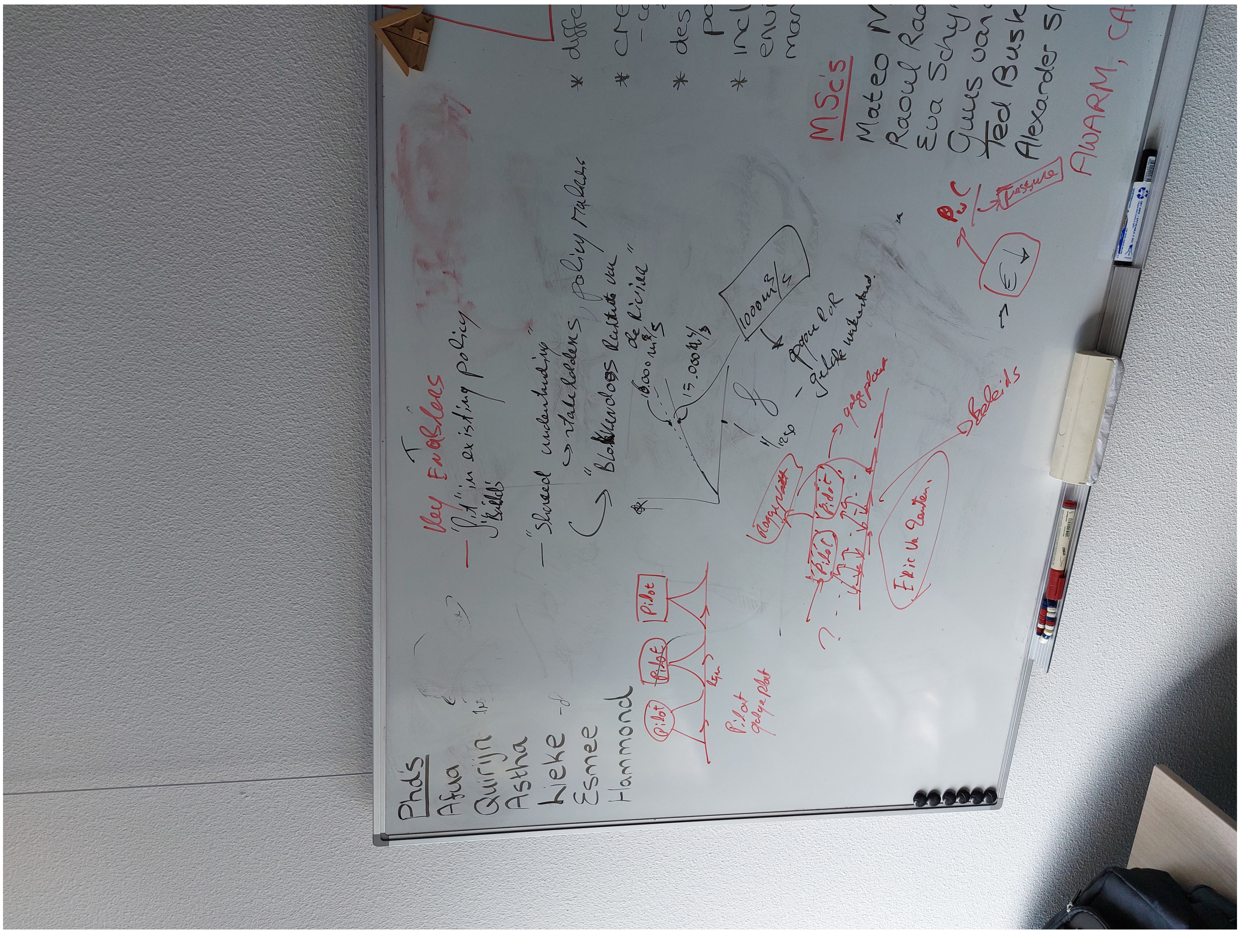

Figure B.2: QL photo 2

C

Interview Carola van Gelder

C.1. Could you start by introducing yourself? Name, job description and connection to the Sand engine, Building with nature and Pilot projects?

Name is Carola van Gelder, she works for Rijkswaterstaat, at Waterverkeer & Leefomgeving (Water traffic and living environment) in the department Hoogwaterveiligheid (High water safety). This department mostly works on the daily management and maintenance of coasts and rivers and performs strategic research and strategic process coaching. They are also policy advisors for the ministry. This last part is her main role, specifically on the Dutch coast. She is the program manager for monitoring and evaluation of the Sand Engine project, as well as the project Zandige kust (Sandy coast) which is a part of the knowledge program Zeespiegelstijging (Sea level rise). In this program they try to improve or upgrade the current management and maintenance methods of the coast and to make it adaptive to the sea level rise. Besides this, she is part of multiple international projects, NWO-proposals and scientific studies, all focused on the coast. She has been project leader of the Sand Engine project since 2012, to lead the monitoring and evaluation of the project. She sees it somewhat as her 'baby'. She studied Geo-hydrology in Amsterdam, at the Vrije Universiteit. (06:15)

C.2. How do you view Building with Nature as a concept? Do you encounter it a lot?

She encounters it increasingly. She is one of the few/earliest who got into contact with BwN, because of the Sand Engine project from 2011. It was a pilot, the way it was performed had never been done before and you can see that in the past 10 years there have been so many spin-offs within the Netherlands but also abroad. This is not copy pasting the project, but thinking about utilising natural materials for strengthening, management and maintenance ops up everywhere. She has tried herself to utilise and embed this in new projects, NWO proposals and projects abroad. So, in her view, the Sand Engine has contributed to this spread of BwN, it is such an iconic project that it helped speed up other nature based solutions.

C.3. Why do you perceive the Sand Engine as a successful project, are there other pilots you perceive as successful and what makes them successful?

The Sand Engine is a success. Before 1990, there was coastal policy, but not like we have now. Because of the increasing erosion along the coast, the ministry decided that they wanted to keep the coast where it was at that moment and that is currently still the policy: The base coastline. The coast gets nourished with 12 million cubic meters of sand every year. Not only to maintain the coast, but also to grow the coastal foundation. This policy is successful, the erosion get negated but the pressure

on the coast became bigger, not only due to sea level rise but also from in-land. People want to live and work near the coast. So, they were looking for a way to put all these functions in one solution and wound up with BwN, which led to the Sand Engine. As a pilot together with the South-Holland province, it protected the coast, created more nature and space for recreation. The success was not the fact that it was made, because the technical part was not the problem. The success was in the fact that it provides value for multiple functions: Coastal defence, nature, recreation, economy, underwater ecology, knowledge development.
This success was not guaranteed. The project was not popular with everyone in the beginning. 'The coast had just been strengthened and now they're going to drop a load of sand there for 50 million euros'. Especially the local residents had a lot of worries and questions. To resolve this, Carola states that communication and education was very important: Why are we building this, what are we going to measure and how are we going to manage it. A big promise was, if it goes wrong, we will intervene. A technique that was used is giving the residents co-ownership of the project, to attach them to it. So, the communication around the Sand Engine is also a success. Even more, the Sand Engine would not have been such an success without this communication. (15:00)
Different pilots: Hondsbossche en Pettemer zeewering, was strengthened with sand so also nature based solution. This could be seens as a direct spin-off of ideas and knowledge from the Sand Engine, even though it is a totally different type of project. Amelander zeegat was another. Smaller than the sand engine, but very important to RWS with eyes on the future. She sees it as successful, even though it is smaller, because it has become policy. (17:40) Markerwadden and the Houtribdijk are also succesfull pilots which can be traced back to the Sand Engine. Same goes for projects abroad, in England, Sweden and Congo there are projects related to the Sand Engine (Congo is an error, this must be the coast of Togo and Benin, https://www.dutchwatersector.com/news/sand-engine-principles-to-replenish-african-coastline).

C.4. What are factors for success for a pilot

Success could be: Can we carry out the project? But also, does it reach the goal that is the reason it was made? Does the sand behave in a way we hoped it would? But also, it is a success because RWS saw that it worked, so they want to do it more often: It has become policy. (19:20) Factors for this success are: communication, like i the Sand Engine pilot. The used this knowledge in the project at the Amelander zeegat and began communicating with the locals at a much earlier stage, which led to zero complaints during the project. Another factor, especially for the Sand Engine, is the multi-functionality. Otherwise, it would have been way too expensive, redundant and would not have check for possible other benefits from other functions.

C.5. Was this multi-functionality a design choice from the start, or was it added later to close the business case

The multi-functionality was a design choice since the very beginning, otherwise the project would have been a very expensive pilot for a single goal and would probably have not existed. It was also designed in collaboration with multiple parties, Ecoshape, Tu Delft, Rijkswaterstaat etc.

C.6. How does the Sand Engine project stand in the time-context of dutch coastal management

She has a nice picture of the timeline of the Dutch coastal defence. It is a graph over time with the amount of sand on the y-axis. since 1990, the amount of sand has been steadily increasing. Starts with beach nourishments, Fore shore nourishments, Geulwand (Gully wall) nourishments, system nourishments like the sand engine(Large scale nourishments) and it ends with buiten-Delta (Outside delta) nourishments, like Ameland. So the development has been in scale, multi-functionality and longer duration. These pilots are not just for testing: Can we do it?, but also: How is the system going to react, is it going to behave like in the models? The Netherlands is unique, in the way that it is possible to perform these big pilots and put them to the test. In other countries it is either do it without trying first, or don't. A key factor that enables this, is the fact that the government is responsible for the coastal safety of the entire coast. In most other countries it is the responsibility of either the land owners (England) or the local municipalities (Sweden). Close tied to the relation with water in the Netherlands

C.7. Model Questions

C.8. Is there a trade-off between the practical side and the process side of pilot projects?

The two sides can not exist without each other. It also depends on who is the project owner, who wants the pilot. If there are multiple owners, you already have and need a process. You can not build something without talking to other actors and stakeholders. This always leads to changes in the initial, practical, project plan due to new information and wishes from other parties. Carola does not see this as competition, more like succession. This fits with the bigger loop of the model, initial design leads to conversations. New knowledge on the project gets created and shared by the involved parties, shared group knowledge. This shared group knowledge leads to redesign of the initial project.

C.9. With increased redesign, the project becomes more rigid and less open for new redesign

Yes and no. The Sand Engine was a special case, because before its construction an agreement was signed by the involved parties which stated that the Sand Engine would not be altered after the construction to really be able to monitor what is happening. A clause here was that if processes with large negative consequences would arise, they would intervene. The initial design was made, constructed and after that, it was left to itself. So it could be seen as both rigid, because they would not change anything, and as flexible, because they let nature run its course with the pilot. They did however, take some control measures to ensure that things did not go wrong. (43:00)

C.10. Did the monitoring and measuring information of building the Sand Engine get shared with all the actors and used in adapting the project design?

Yes, absolutely. This was a continuous back and forth of noticing things and making alterations, even in the monitoring program itself. Some parts of the monitoring program did not provide valuable enough information for its cost and were cut, others were added. (45:00).

C.11. Relevant knowledge of individuals, good facilitation and an open learning space are important factors for a high quality of interaction within a project. Do you recognise this?

She recognised this in the Sand Engine project and sees it as a contributor to the success of the project. The open ambiance, high level of knowledge in the project through knowledge institutes and universities, Facilitation through knowledge meetings two times a year. The openness was important, dialogue was important and RwS was open to suggestions and would take it to heart. The facilitation was done is such a way that it was very open, but at the same time very structured and this worked well.

C.12. Do you recognise that an open learning space enforces the quality of engagement and vice versa?

Carola recognises this. An open learning space made participants part owner of the Sand Engine pilot project and instills a sense of pride about their work on it. It was also agreed that everyone, in deliberation of course, could talk and present about the Sand Engine. However, they did agree on a certain line in which the project would be presented so there would be no surprises. She sees this as integral part of the open learning space and this was a work in progress during the project; learning by doing. Things happened, but instead of fighting each other, they took it as a learning opportunity and deliberated together about how to prevent it in the future. This built trust and openness in the interaction.

C.13. Do you recognise the commitment reinforcing loop? Do you see the championship of knowledge increase the institutional commitment?

(55:00) It happens, but mainly in the knowledge institutes and universities. these organisations have the room for this kind of innovation. Private companies usually have this room in lesser amount. The people do have the willingness to use the acquired knowledge, but getting it internalised in an private organisation is harder than in an university or knowledge institute. It does happen though. Witteveen Bos saw how data management worked in the Sand Engine project and recognised its potential as a better business case than they had used before. So it has happened, but it is not the norm.

C.14. For internalising a idea/concept from the pilot project, is the perceived success enough? Or are there other factors?

A helping factor according to Carola was the iconic status of the Sand Engine (Stakeholder resonance). So much knowledge was and was going to be developed there, that the organisations were open to develop this knowledge further in their own organisation and try it out. Similarly, the future plans of RwS for the Dutch coast are no secret, so it is in the interest of organisations to acquire knowledge which fits these plans, tot be able to land RwS tenders in the future and build their business case.

C.15. Does the implementation of policy in organisations result in rigidness for new policy?

She thinks it works like this, especially in smaller market parties. It depends on how much room there is in an organisation, sometimes the project line-up is just full and things get dropped. When they noticed that the Sand Engine was a success, ideas got pitched to do the same in North-Holland but these got blocked for the time being, because they first wanted to see how this first Sand Engine would turn out. On the other hand, knowledge from the Sand Engine was used at Amelander Zeegat. So there is continuation, but maybe at a smaller scale and only if there is a clear reason to do so.

C.16. For the main loop of the model, does this fit with reality? Is anything missing? What would you add or take away?

What comes to mind for Carola is the Plan-Do-Check-Act cycle. A Design is made, it gets realised, it gets monitored and changes are made accordingly after which the loop starts again. This loop is a standard way of working within RwS.(1:08:00)

C.17. These guidelines for the check part, are these static? Or do they change during the process?

These are moving guidelines. The initial Check-points are decided upon in the beginning, what criteria are we going to check on. On the other hand, new things emerge, like kitesurfing at the Sand Engine which is a valuable recreational en economic activity there, which become new criteria to check on. This is part of the plan-do-check-act cycle, which cycles approximately every year. So these guidelines are not at all static, but they are your support.

C.18. Is there anything missing in your opinion?

What is less clearly visible or present is the stakeholder involvement, which is very important in any project. At the Sand Engine, how is the province acting and what are they doing with the knowledge and the opportunities presented by the Sand Engine?

D

Interview Lotte Bontje

D.1. Could you start by introducing yourself? Name, job description and connection to the Sand engine and Pilot projects?

Lotte Bontje, She studied spacial planning at Wageningen university and got a teaching degree in geography. She started working at Oranjewoud, now Antea groep, and after some time (2013) she started at the Naturecoast program in a PhD position on the governance part of the Naturecoast program. Her PhD was on the governance of coastal management and the role narrative and stories play there, with the Sand Engine as focal point. (11:00). The main goal of her research was: I want to improve the insight in the development of pilot projects and their effects in their actor network. There are three narratives in play: first of all, there are stories in an actor network working on pilot projects, they have to get their organisation on board with the project with a good story. Second, she performed open interviews and asked people involved with the project to tell their view of the story of the Sand Engine. Lastly, narrative returned in the way of analysis of these interview. The key result of her PhD was the fact that the Sand Engine was an outdoor 'stage', on which stakeholder could receive guest and show their project. This helped immensely with spreading the stories. Combined with this is that the Netherlands is very sensitive to these stories, its resonance was very high. Compared to a project in Sweden, this did not occur at all and the project there did not take off like the Sand Engine. One reason is that coastal management is done on a municipality level instead of national and large parts of Sweden are still bouncing back since the age age, so there is no relative sea level rise. So the narrative on coastal erosion is much different there than in The Netherlands. Also, ecologists and biologists are much more prominent in the government there compared to the Netherlands, who were much more apprehensive about sand nourishments. Furthermore, the Sand Engine was in line with Dutch policy, it was scaling up techniques which already existed. In Sweden it was way more new, sand nourishments had rarely happened there at a sizable scale. (20:00)

D.2. What is your connection with Building with Nature?

Naturecoast was a sort of successor of BwN. But she did not have much interaction with the program. (24:00).

D.3. What makes a pilot project successful and what are factors for this success

(30:00) At the point in time she was working on it, the narrative was an factor for the success the Sand Engine. The facts mentioned above that the Sand Engine was this 'stage' and that the Netherlands as a country is sensitive to stories on coastal management, because we think we are good at it, creates this self-fulfilling prophecy and helped the perceived success of the project.

D.3.1. What projects came before the Sand Engine?

She interviewed a lot of people about their 'story of the Sand Engine'. In these stories the interviewees talked about what projects led to the Sand Engine being realised. One thing everyone mentioned is the fact that sand nourishments were already being performed on the Dutch coast, so some saw the Sand Engine as the next step, but others saw it as an iconic new step in coastal management. Most people in the field recognised the first narrative. (35:00)

Factors for success

One factor could be that the Sand Engine was not too new, but also new enough to tell good stories about which helped people get on board. Furthermore, it has to do with the actor dynamics and the fact that stakeholders became enthusiastic and were used to 'selling' the project so to speak, because they had to do that to get the Sand Engine project started in the first place. The fact that project was so multi-functional helped with this as well. Because every actor could take one of the functions that fit their goals and highlight it in their narrative. A foreshore nourishment for example is more one-dimensional and not as easily framed for different purposes. (39:00) There were different variants of the Sand Engine design before the final design was chosen, one was a giant foreshore nourishment and another a straight broadening of the beach. Lotte thinks that the hook-shape won, because it is more exciting to walk on the hook than a broadened beach which creates recreational value and the lagoon created ecological benefits. So this was the most multi-functional of the designs.

D.4. What did you mean by the term resonance?

Both the Dutch success stories or the Swedish restraining narrative are a result of how the ideas resonate in the actor network. These stories circulate in these networks and resonate there. Each actor network is connected to others, so these stories and narratives move way beyond the initial actors involved with the project and stay (resonate) longer than the duration of the project (46:00).

D.5. Model questions

D.6. How was the knowledge program? Did it lead to an open learning space which strengthened itself through its success?

There were two main knowledge programs, Naturecoast and a monitoring program by RwS. There was a lot of interaction through congresses by EcoShape for example. You could check which articles are published together by RwS and Naturecoast (51:00).

D.7. Do you recognise that champions of knowledge come from the Pilot project and increase their organisations commitment?

After defining knowledge not just as new breakthroughs in science and scientific knowledge, but also just knowledge about a possible way of working which could improve the current methods, Lotte recognises this relation. She also states that the direction of this relation depends on the organisation. Some organisations got swept along with the enthusiasm in the Sand Engine project, while others were already intrinsically motivated for it and had a more driving role. Pilot projects need people who will push for the pilot project to be realise, while at the same time, actors in the project learn a lot and take this knowledge back to their organisations. She sees how this can work in both directions. RwS is an example which is very good at promoting knowledge internalisation in their own organisation and a innovative mindset throughout. This fits the image of The Netherlands as a water-land with RwS as figurehead. Another thing was that all the PhDers involved with Naturecoast and the Sand Engine were also part of all kinds of different organisations and universities. So they took the knowledge of the Sand Engine back to these institutions and spread it there through lunch-lectures etc.

D.8. From the internalised knowledge, policy and procedure suggestions are made of which some make it into implemented policy and procedure. This creates rigidness which impedes the suggestion and implementation of new policy. Do you recognise this?

She recognises it in a way, but is doubtful about it happening a lot or very fast. The impact of pilot projects could be too small to creates this effect and it depends on the type of organisation. (1:07:00)

D.9. For the main loop of the model, does this fit with reality? Is anything missing? What would you add or take away?

She was not at the design of the project. But as a group, they had sessions in which they started to make a new design for the Sand Engine, with the knowledge they had acquired in their research. It was more of an exercise, but people were put together to work with the knowledge from the project. RwS has internalised knowledge from the Sand Engine very well and has applied it on new projects like the Houtribdijk, Hondsbossche en Pettemer zeewering and the Amelander zeegat. So there, the loop from pilot knowledge, to organisational learning and to policy is clear.