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CO-DESIGN IN THE COASTAL CONTEXT

FLOORTJE d'HONT

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Co-design in the coastal context

Dissertation

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CONTENTS

SAMENVATTING

Waarom bestuderen we co-design activiteiten in kustverdediging?

In dit proefschrift onderzoeken we 'co-design' en hoe die de ontwikkeling van oplossingen voor kustbeheer versterken. Het onderzoek heeft zowel een wetenschappelijke bijdrage alsmede een bijdrage voor de praktijk, en focust specifiek op Nederlands kustmanagement. De keuze voor Nederland is gemaakt om een aantal redenen. Ten eerste is de praktijk van kustbeheer in Nederland zeer intensief, onder andere om de kustlijn op haar plaats te houden, om het land tegen de zee te beschermen, en om infrastructuren te bouwen die (nu en op de zeer lange termijn) een wenselijke leefomgeving bieden. Hierbij hoort ook het uitgebreide zandsuppletieprogramma, waarmee de kustlijn wordt aangevuld met extra sediment om erosie tegen te gaan. Omdat Nederlands kustbeheer hoofdzakelijk een preventieve exercitie is om de kusten te verdedigen tegen overstromingen, noemen we 'kustbeheer' in deze Nederlandse samenvatting ook 'kustverdediging'. Ten tweede is Nederland een wereldleider voor management van kusten en kustverdediging, wat noodzakelijk is, vanwege kwetsbaarheid van het land, de laaggelegen gebieden en de hoge mate van verstedelijking in de kustzones in Nederland. Ten derde is er sprake van een al lang bestaande, consensuszoekende stijl van bestuur, en een hoge mate van burgerparticipatie in beleids- en ruimtelijke ontwikkelingen. Maar ondanks de sterke participatieve traditie in Nederlands kustbeheer, wordt samen ontwerpen met lokale actoren weinig gedaan. Wetenschappelijke kennis die voorschrijft hoe zulke activiteiten te ondernemen ontbreekt. Ten slotte is het kustsysteem ingebed in sociale en ecologische systemen, die dynamiek vertonen op verschillende schalen, wat toevoegt aan de complexiteit van (het conceptualiseren van) het kustsysteem.

We onderzoeken design-georiënteerde activiteiten die gericht zijn op het gezamenlijk vinden van innovatie kustverdedigingsoplossingen (co-design). De complexiteit en context-specifieke eigenschappen van kustmanagementproblemen, schrijven op maat gemaakt co-designactiviteiten voor. Daarom is het algemene onderzoeksdoel te begrijpen hoe we co-designactiviteiten in de context van kustmanagement kunnen ontwerpen en versterken.

Onderzoeksaanpak

Dit onderzoek bestaat uit drie delen: een theoretische analyse, een verkenning van de praktijk en een reflectie. We leren van de praktijk middels het ontwerp, de organisatie, de toepassing en de analyse van een co-designproces in de vorm van drie complementaire co-designworkshops (de primaire casestudy). Deze bevindingen worden aangevuld door andere gezamenlijke activiteiten te observeren binnen de kustmanagement context: 'de secondaire activiteiten'. Deze noemen we met nadruk geen 'casestudy's', omdat ze activiteiten observeren die niet alle elementen van co-design bevatten.

Wat is co-design?

Het eerste deel van het proefschrift, de theoretische analyse, verkent het begrip 'co-design', en trekt inspiratie van verschillende onderzoeksgebieden, zoals bijvoorbeeld participatief design onderzoek, engineering design en andere (participatieve) methoden in een milieucontext. Dit onderzoek karakteriseert 'co-designactiviteiten' als specifieke, gezamenlijke, en ontwerpgerichte prestaties, afgebakend in tijd en omvang. Door verschillende actoren te betrekken in het co-designproces, zoals bijvoorbeeld beleidsmakers, professionele experts van verschillende (vak-) gebieden, en/of inwoners van een bepaald kustgebied, draagt een co-designproces bij aan kennisuitwisseling over disciplinaire grenzen. We nemen aan dat een goed ontworpen co-designactiviteit die past bij de specifieke kustomgeving in potentie tot de beoogde uitkomsten kan leiden. Hiermee impliceren we een indirect causaal mechanisme tussen ontwerpprincipes en voorgestelde uitkomsten, wat toe te schrijven is aan de complexiteit van sociale activiteiten.

Wat is de theoretische belofte van co-design activiteiten?

Ten eerste zouden co-designactiviteiten potentieel kunnen bijdragen aan **het begrijpen en betrekken van de complexiteit van het natuurlijke systeem in een kustmanagementoplossing**. Onder de complexiteit van het natuurlijke systeem worden bijvoorbeeld de interrelaties tussen de ecologische en geofysische systemen verstaan. Co-design zou ook (gedeeld) inzicht kunnen verschaffen in het vermogen van het geofysische systeem om de diversiteit en kwaliteit van de habitatten te behouden. Een ander mogelijk inzicht is de invloed van het externe milieu op het, praktisch afgebakende, kustsysteem. Daarnaast zouden co-designactiviteiten bij kunnen dragen aan (verbeterde) vertegenwoordiging van externe factoren, zoals klimatologische of meteorologische invloeden die expliciet worden meegenomen.

Ten tweede kunnen co-designactiviteiten bijdragen in de categorie **van de complexiteit van het sociale systeem**. Het sociale systeem omvat zowel het bestuurssysteem, als het systeem dat bestuurd wordt. Co-designactiviteiten hebben de potentie om kennis over waarden, perspectieven en dilemma's van actoren te adresseren. Daarnaast kunnen ze vertegenwoordiging van lokale en inheemse kennis over het kustgebied in de co-designactiviteit faciliteren, van zowel betrokken als niet-betrokken actoren. Wat betreft het bestuurssysteem, kunnen co-designactiviteiten de verschillen en interrelaties tussen sociale-, institutionele- en bestuurs-subsystemen adresseren. Uiteindelijk zouden de oplossingen die resulteren uit co-designactiviteiten gelinkt kunnen worden met de beleidscontext.

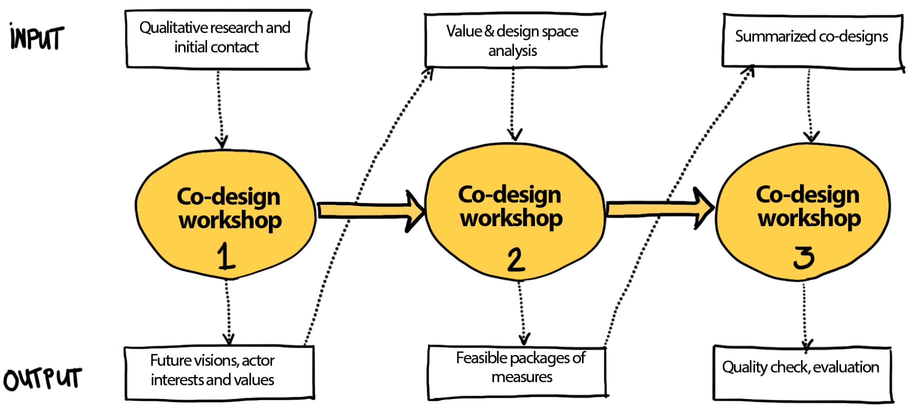
Ten derde kunnen co-designactiviteiten op verscheidene manieren bijdragen aan **kennisdeling**. Kustbeheer is bekend met integratie van verschillende kennissoorten, maar dit blijft bij tijd en wijle uitdagend. Indien goed uitgevoerd, kunnen co-designactiviteiten bijdragen aan het delen en verspreiden van bestaande sociaal- en natuurwetenschappelijke kennis over kustsystemen. Identificatie van relaties tussen systemen, subsystemen en systeemelementen dragen bij aan verbetering van de systeemkennis. Co-designactiviteiten dragen ook bij aan identificatie van de mogelijkheden die de huidige instituties bieden, en restricties die ze opleggen, voor oplossingen. Zo zouden oplossingen met betrekking tot de sociale (multi-actor, bestuurs- en institutionele complexiteit) kant van het complexe kustsysteem op deze manieren eerder overwogen worden.

Kennis van het kustsysteem wordt in dit onderzoek nadrukkelijk beschouwd als iets in de Nederlandse context van kustbeheer dat kan helpen met het verbeteren van kustoplossingen, en dat kan worden vermeerderd en gedeeld tussen wetenschappers, experts en (lokale) belanghebbenden. In dit proefschrift verkennen we de link tussen de praktijk en de theoretische belofte van co-design, namelijk: het begrijpen en betrekken van de complexiteit van het natuurlijke systeem in een kustverdedigingsoplossing, van het sociale systeem, inclusief de waarden en perspectieven van actoren, en om kennisdeling te faciliteren en verbeteren.

We vestigen de aandacht op het gebruik van een systeemaanpak om zeer diverse activiteiten te vergelijken, die ingebedde problemen adresseerden met complexe sociale en bio-geofysische dynamiek. Daarnaast beschrijft de theoretische belofte de kennisdeling en de integratieve natuur van (kennis) tussen de subsystemen die relevant zijn in de context van de kust, leunend op een transdisciplinaire aanpak. Zodoende verwezenlijkt de theoretische belofte een holistische manier om de realiteit te conceptualiseren, onderbouwd door sociaal-ecologisch systeemdenken en transdisciplinariteit.

De primaire casestudy op zuidwest Texel

De primaire casestudy omvat het ontwerp, toepassing en analyse van een co-designproces voor een kritiek erosiegebied op zuidwest Texel. Dit co-designproces betrok actoren zoals wetenschappers, ingenieurs, mensen uit de lokale gemeenschap en andere experts. Samen heroverwogen zij een nieuw multifunctioneel concept dat onder andere een nieuw soort 'geconcentreerde sedimentsuppletie' zou betekenen in



Figuur i Co-design aanpak voor het co-design proces op zuidwest Texel de mariene omgeving – verder van de Texelse kust vandaan – om kusterosie tegen te gaan op een manier die ook sociale voordelen (zoals het stimuleren van recreatie en natuur) met zich meebrengt.

De primaire casestudy bood de mogelijkheid om te experimenteren met een co-designproces dat was losgekoppeld van, maar parallel aan, een daadwerkelijke besluitvormingsproces.

Co-design voor de casestudy van zuidwest Texel gebeurde in een proces van drie complementaire workshops (zie Figuur i). In de eerste workshop ontwikkelden lokale belanghebbenden ('lokale experts') utopische en dystopische toekomstvisies voor het eiland, geholpen door experts met kennis over verschillende aspecten van het kustsysteem van en rond zuidwest Texel. In de tweede workshop namen disciplinaire experts (waaronder bijvoorbeeld kustingenieurs, experts van institutioneel ontwerp, ecologen) het ontwerpstokje over. In interdisciplinaire groepen maakten zij nieuwe co-ontwerpen als iteraties op de uitkomsten van workshop 1 en additionele informatie over lokale waarden. De derde workshop gold als een validatie. De lokale deelnemers beoordeelden de resultaten en gaven feedback op het verloop van de eerdere workshops en het gehele proces.

Elk van de drie individuele co-designworkshops en het gehele co-designproces droegen bij aan de uitkomsten van de primaire casestudy. De geobserveerde uitkomsten dragen bij aan verbeterde kennisdeling, een toename van kennis van het bio-geofysische systeem, een dieper begrip van de sociale belangen die op het eiland spelen en de perspectieven van actoren waren een terugkerend onderdeel van het proces, en een uitgebreid begrip van de complexiteit van het systeem. Daarnaast zijn er een aantal indirecte effecten geobserveerd in het actornetwerk, met name met betrekking tot leren en het vormen van coalities (zie ook Vreugdenhil, 2010; Cunningham et al, 2014). Een van de meest opvallende resultaten van het co-designproces op zuidwest Texel was het inzicht dat het verschaf in onderliggende en veronderstelde stakeholderperspectieven. Waar de belangen van één specifieke stakeholder (restauranteigenaar) aanvankelijk werden gezien als een belangrijke beperking, werden later in het co-designproces dominanter beperkende factoren geïdentificeerd, waaronder de positie van het waterschap over de gelijke behandeling van ondernemers. Zodoende werd de oplossingsruimte verbreed van veranderen van suppletiestrategieën (interventies in de fysieke omgeving) naar het aanpassen van (gemeentelijke) regelgeving rond bestemmingsplannen (interventies in de overheids- en instutitionele systemen). Wat we echter niet zagen, was of die bredere ontwerpruimte daadwerkelijk werd ingezet in een kustbesluitvormingscontext. Bovendien waren de effecten van het co-designproces op kustbeheer in de praktijk gelimiteerd, omdat het experiment op zuidwest Texel expliciet gepositioneerd is als parallel (en indirect) aan een besluitvormingsproces.

De bijdrage van co-design activiteiten aan kustbeheer

Naast de uitgebreidere primaire casestudy, zijn ook een viertal secundaire casestudy's geobserveerd, geanalyseerd en geïnterpreteerd – de secundaire activiteiten: Negril Bay Jamaica (A), Kerngroepmeeting Schelde-estuarium (B), Rekennormen voor zandsuppleties voor de Nederlandse kust (C), en op de Slufter, Texel (D). Deze vier activiteiten zijn gerelateerd aan kustbeheer en doelden op samenwerking tussen mensen van verschillende achtergronden. Alle vier de secundaire activiteiten bevatten groepsdiscussies in de vorm van workshops.

De secundaire activiteiten zijn geïnterpreteerd met behulp van de theoretische belofte van co-design. Bij het vergelijken van de secundaire activiteiten zien we bijvoorbeeld dat een gebrek aan waardering voor kennis van de specifieke lokale context inderdaad resulteert in onvolkomen designs. Deze kennishiaten traden bijvoorbeeld op in de Negril Bay (activiteit A), toen gebrek aan inzichten over de perspectieven en belangen van de lokale stakeholders, alsmede gebrek aan specialistische expertise over koraalriffen, resulteerden in onvolkomen oplossingen voor een kustverdedigingsprobleem op Jamaica. Desalniettemin traden er leereffecten in deze activiteit A op. Over de procesaspecten van de workshop werd geleerd, net als over bijvoorbeeld de beperkingen van de generaliseerbaarheid van Nederlandse zandsuppletieconcepten. Daarom concluderen we dat zelfs als de uitkomsten van de activiteiten beperkt zijn, of zelfs als 'mislukt' beschouwd worden, leereffecten nog steeds kunnen optreden.

We leerden dat design-georiënteerde activiteiten die gericht zijn op het gezamenlijk vinden van innovatie kustverdedigingsoplossingen bestaan in de Nederlandse kustbeheercontext. We nemen hierbij in aanmerking dat zulke activiteiten zeldzaam zijn – met name als het gaat om co-designactiviteiten die het sociaal-ecologische gezichtsveld omarmen. Ondanks de grenzen aan het empirische materiaal hebben we gepoogd te leren van activiteiten die transdisciplinaire samenwerking nastreefden. In alle gevallen leidden de activiteiten tot kennisdeling, en in sommige activiteiten tot oplossingen die verschillende elementen van het complexe kustsysteem kunnen beoordelen – inclusief het overwegen van waarden van actoren en andere sociale complexiteit. Zodoende hebben co-designactiviteiten potentie om een bredere oplossingsruimte te identificeren. Dit observeerden we bijvoorbeeld in de activiteiten die zich richtten op het genereren van ideeën - vroeg in het ontwerpproces. Daarnaast resoneert de kennisdelingspotentie met het gedachtegoed van participatief management en past het bij huidige idealen in kustmanagement (e.g., ICM, Deltaprogramma). Het ondersteunt de premisse dat oplossingen (deels) op de interface tussen bio-geofysische, sociale en governance systemen liggen. Dit geldt in het bijzonder voor complexe problemen waarvoor we oplossingen zoeken die – op de korte en lange termijn - ten goede komen aan het publiek.

De versterking van de contributie van co-design activiteiten aan een kustverdedigingscontext

Vanwege de complexiteit en contextualiteit van kustbeheerproblemen, zijn op maat gemaakte co-designactiviteiten noodzakelijk. In dit proefschrift beargumenteren we dat hoewel het ontwerpen van co-designprocessen vraagt om contextualiteit, het te volgen ontwerpproces algemener is. Daarom geeft de formulering van de ontwerpprincipes een algemene richting aan het ontwerpen van de co-designactiviteiten in specifieke kustbeheercontexten.

De theoretische studie was instrumenteel in de totstandkoming van dertien ontwerpprincipes, die vervolgens zijn getest en aangevuld door middel van de empirische studie. De ontwerpprincipes (zie Tabel) voor co-designactiviteiten zijn manifestaties van de ontwerpvariabelen die een actor tot zijn/haar beschikking heeft bij het ontwerpen van een co-designactiviteit, waaronder: hoe kennis van diverse bronnen is gerepresenteerd (P1; P2; P3; P4); keuzes over deelnemerselectie (P9); keuzes voor methoden (P11); het moment in het ontwerpproces, wat is verweven met het doel van de activiteiten en de relatie tot het ingebedde ontwerpproces (P10); het ambitieniveau voor samenwerking (P12); hoe vertrouwenskwesties aangekaart zijn (P4; P6); de omvang en de scope van het probleem, wat met name problematisch is voor de inherent veranderlijke kust op variërende schalen en niveaus (P5; P6; P7); redenen voor het initiëren en doen van co-design in de context van de kust (P14). De ontwerpprincipes zijn ontwikkeld voor kustverdedigingsproblemen, maar we vermoeden dat ze ook bruikbaar zijn voor andere probleemsituaties die gekenmerkt zijn door complexe systemen. We nodigen andere onderzoekers uit om de ontwerpprincipes te bevestigen, en uit te breiden naar andere contexten.

#	**Ontwerpprincipe**
P1	Betrekken van lokale kennis en lokale waarden
P2	Betrekken van wetenschappelijke kennis
P3	Faciliteren van kennisdeling
P4	Geef de lokale gemeenschap en professionele experts gelijke stemmen en status.
P5	Houd rekening met contextuele specificiteit: betrekken van systeemcomplexiteit (actorennetwerk, 'governance', en bio-geofysisch)
P6	Juiste omvang
P7	Streef transparantie van de relatie met het beleidsproces na
P8	Streef transparant onderzoek na
P9	Juiste selectie van deelnemers
P10	Juiste moment van burgerdeelname
P11	Streef een creatief niveau van betrokkenheid van de toepassing na
P12	Streef voor gezamenlijk leren en gezamenlijke constructie van systeembegrip.

Het empirisch onderzoek leverde niet genoeg op om het dertiende ontwerpprincipe te bevestigen:

#	**Ontwerpprincipe (onbevestigd)**
P13	Vermijd een mismatch tussen de rationaal en doelen *(onbevestigd).*

Daarnaast heeft het empirisch onderzoek ook een additioneel ontwerpprincipe toegevoegd:

#	**Ontwerpprincipe**
P14	Iteratieve reflectie en aanpassingen aan aanpak gedurende de activiteit

Ten slotte

Dit proefschrift doet verslag van de rol en mogelijkheden voor co-designactiviteiten in de context van kustmanagementproblemen. De wetenschappelijke bijdragen van het proefschrift behelzen:

- Een goed ontworpen co-designproces kan in potentie voldoen aan de theoretische belofte van co-design. We zien dit met name in de primaire casestudy op zuidwest Texel, waar diepte van het begrip van subsystemen en hun samenhang stimulerend werkte in het creëren van oplossingsrichtingen die zowel de instituties en beleid als interventies in de fysieke omgeving omvatten.
- Het analyseframework voor co-designactiviteiten in de context van de kust, dat een holistische benadering gebruikt in het conceptualiseren van de werkelijkheid, en is onderbouwd door beleidsanalyse, sociaal-ecologisch systeemdenken en transdisciplinariteit.
- Dit analyseframework bevat ook ontwerpprincipes en identificeert relevante ontwerpkeuzes voor het ontwerpen van co-designactiviteiten, alsmede de theoretische belofte van zulke activiteiten.
- Hoewel gelimiteerd, bevestigde het empirische deel van dit proefschrift de verwachtingen en aannames waarop het analyseframework is gebaseerd.
- Het belang van iteratieve reflectie (P14) is geïdentificeerd, wat het belang benadrukt om ontwikkelingen in het leren te verwerken in de co-designaanpak.
- Het onderzoek identificeerde dat co-design in de context van Nederlands kustbeheer in de kinderschoenen staat. We zagen geen kans co-designprocessen te observeren voor spelende kustbeheerstrategieën. Dit is een indicatie dat er ruimte is om deze co-designaanpak verder te ontwikkelen voor deze context.
- De ambachtelijkheid van het ontwerpen van een co-designactiviteit die de beloofde uitkomsten bereikt, zit in het verbinden van de relevante context aan het ontwerp van de activiteit.

Co-design is een middel voor de totstandkoming van verscheidene doeleinden. We observeerden bijvoorbeeld co-designactiviteiten met als beoogde doel om ingenieursoplossingen gezamenlijk te ontwerpen. In andere gevallen waren de co-design opdrachten ruimer of gericht op de aanpassing van beleid. In het algemeen zien we in dit onderzoek dat co-designactiviteiten bijdragen aan de identificatie van (waarden) dilemma's in de oplossingsruimte, tegenstellingen in (actor-) perspectieven en bredere oplossingsrichtingen. Co-designactiviteiten geven verscheidene actoren de ruimte om samen te werken op een creatieve en open manier. Lokale -, wetenschappelijke-, praktijk- en andere vormen van kennis worden op een egalitaire manier gebruikt in zoektochten naar oplossingen voor de kustzone. Dit proefschrift 'co-design in the coastal context' draagt bij aan inzichten over hoe de co-designactiviteiten te ontwerpen, geeft een reflectie op de beloften die in de literatuur te vinden zijn over co-design in complexe systemen, en biedt bruikbare en handzame methoden om zulke co-designactiviteiten te evalueren.

SUMMARY

Why do we study co-design activities in coastal management?

In this research, we set out to investigate the phenomenon of 'co-design' and explore the applicability of co-design in the complex coastal context. We specifically turn to the Dutch coastal management context, which has several particularities. First, to maintain the coast, to protect land against flooding from the sea, and to build infrastructures that provide a desired living environment now and in the long-term future, the Netherlands knows intensive coastal management practices. These include extensive nourishment of the coast with sandy sediment. Second, the Netherlands occupies a leading position worldwide in coastal management and flood defence developed as a response to the vulnerability of the low-lying land to flooding and the high density of urban development in the coastal zone. Third, the Netherlands is characterized by a consensus-seeking style of governance with a high degree of public participation in policy and spatial development, in which collaborative activities fit. But even with the strong tradition of participation in Dutch coastal management, designing with local actors is not recognized in this field, and scientific knowledge that prescribes how to undertake these activities is lacking. Finally, the nested social and ecological dynamics associated with coastal problems exhibit different scales, adding to the complexity of conceptualizing such a coastal system.

We have turned to investigating design-oriented, collaborative activities aimed at innovative coastal solutions (co-design) and how they strengthen the development of solutions for coastal problems. As the complexity and site-specific nature of coastal management requires tailor-made, contextual co-design activities, the overarching research objective is to understand how to design and strengthen co-design activities in a coastal management context.

Research approach

The research is divided into three parts, namely: a theoretical exploration, an exploration of practice and reflection. We chose to learn from practice by designing, organizing, applying, observing and analyzing the co-design activities in the primary case study (southwestern Texel). We supplement the findings of a primary case study by observing other collaborative activities in the coastal management context: 'the secondary activities'. These we do not term case studies, because they are observations of single activities which may not have all elements of co-design present.

What is co-design?

The theoretical analysis forms the first part of the thesis, and explores the concept of 'co-design', inspired by literature from different fields, such as participatory design research, engineering design and other participatory methods in an environmental context. A broad definition of co-design activities as specific collaborative design-oriented activities confined in space and time is adopted. By involving different

stakeholders such as policy makers, disciplinary specialists and coastal residents from a particular area in diverse stages of a co-design activity, knowledge exchange across disciplinary boundaries occurs. We assume that a well-designed co-design activity that fits its coastal context can potentially influence the application and as such, would lead to desired outcomes, implying an indirect causal mechanism between design principles and envisioned outcomes, owing to the contextual complexity of such social activities.

The theoretical promise of co-design

First, co-design activities can potentially contribute to enhancing the **understanding of the natural system** and its complexity. The natural system complexity includes for instance the interrelations between the ecological and geophysical systems. Co-design can provide (partial) insight in the ability of the geophysical systems to maintain the diversity and quality of habitats characteristic of the ecological system. Another potential insight involves the environmental impacts on a complex coastal system, within practical spatial bounds. Moreover, co-design activities have the potential to contribute to improved representation of external influences, such as meteorological impacts and climatological impacts on the coastal system.

Second, co-design activities can contribute in the category of enhancing the shared **understanding of the social system** and its complexity. The social system comprises the managing system, and the system to be managed. Co-design activities have the potential to address knowledge on values, perspectives and dilemmas of actors. Moreover, they can facilitate representation of local and indigenous knowledge on the coastal area. In relation to the managing system, the co-design activities can address the differences and interrelations between social, institutional, and governance system elements. Eventually, solutions that result from co-design activities can be linked to the policy context.

Third, co-design activities can enhance **knowledge sharing** in various ways. Despite the familiarity of coastal management with integration of various knowledge sources, knowledge sharing remains challenging. When designed and executed correctly, co-design activities can potentially contribute to sharing and dissemination of various types of scientific knowledge. Identification of relations between systems, subsystems and system elements contribute to enhancing system understanding. Co-design activities can also contribute to identification of the opportunities and constraints offered by current institutions to solutions. Earlier consideration of issues relating to the social (multi-actor, governance, and institutional complexity) side of the complex coastal system will improve co-designed solutions.

Coastal system knowledge is in this research emphatically viewed as something in the Dutch coastal context that can help improving supported design solutions, that can be increased, and that can be shared between scientists, experts and (local) stakeholders. In this thesis we explore the link between practice and the theoretical promise of co-design methods to address key elements, namely: to enhance understanding of natural system complexity, to enhance understanding of social system complexity, including actors' values and perspectives, and to improve knowledge sharing.

Note that a systems approach was used in seeking to compare diverse collaborative activities, each exhibiting nested-scale problems with complex social (pt. 2) and bio-geophysical (pt. 1) dynamics. Additionally, the theoretical promise addresses the integrative nature and the linkages between the social, bio-geophysical and governance aspects that are relevant in a coastal context and knowledge sharing (pt. 3)– specifically addressing a transdisciplinary systems approach. As such, the theoretical promise provides a conceptual lens that embodies a holistic way of conceptualizing reality underpinned by social-ecological systems thinking and transdisciplinarity.

The primary case study on southwestern Texel

The primary case study involves the design, application and evaluation of a co-design process, focused on an erosion hotspot on southwestern Texel. The co-design process involves the local community, researchers, scientists in re-thinking a new multi-functional concept that involves depositing a more 'concentrated sediment nourishment' in the marine environment, further out from the coast of Texel Island, to counter coastal retreat and to provide social benefits (e.g., recreation and nature) over time.

The primary case study offered the opportunity to experiment with a co-design process that was decoupled from, but parallel to, an actual decision-making process.

We chose to do a participatory co-design activity that engaged citizens, scientists, engineers and other experts. The first workshop, local participants ('local experts)

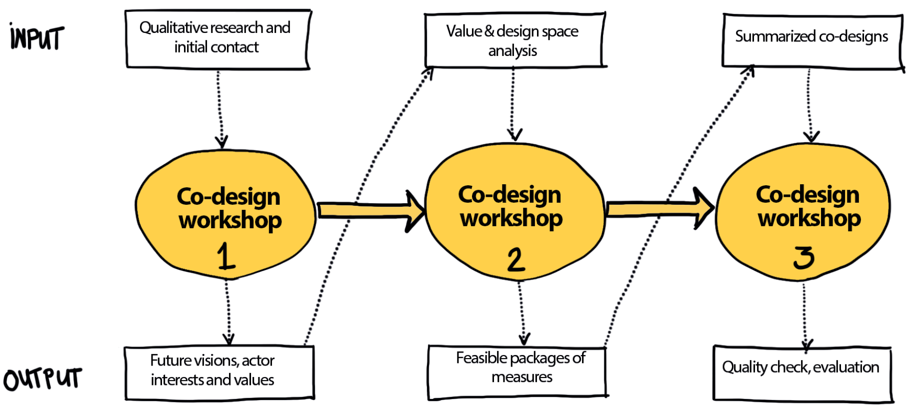


Figure i *Co-design approach for the co-design process on southwestern Texel* co-designed utopian and dystopian future visions for the island, advised by disciplinary experts with knowledge on various aspects of the coastal system of SW Texel. In the second workshop, disciplinary experts continued the design process. They co-designed new iterations in interdisciplinary groups, from the outcomes of co-design workshop 1, and additional information about the local values. The third workshop allowed the participants to assess and give feedback on the appropriateness of the delivered designs, and to give feedback to the entire co-design process.

Each of the three individual co-design workshops and the entire co-design process contributed to the outcomes of the primary case study. The observed outcomes in the primary case study include enhanced knowledge sharing, increased knowledge of the bio-geophysical system, a deeper understanding of the social complexity, include the recognition of actor values as a thread running through the co-design process, and a more comprehensive way of considering system complexity. Additionally, ripple effects into the actor network were observed, especially in the learning and coalition building (see also Vreugdenhil, 2010; Cunningham et al., 2014). Indeed, one of the most striking outcomes of the co-design process on southwestern Texel was the insight in underlying assumptions of stakeholder preferences. Where the interests of one particular stakeholder (restaurant owner) were initially seen as a constraint, towards the end of the co-design process the more dominant constraining factor was identified as the water board's stance about the equal treatment of citizens and entrepreneurs. As such, the solution space was broadened from changing nourishment strategies (interventions in the natural context) to potentially changing municipal zoning rules (interventions in the institutional and governance context). What we did not observe, however, is whether that broader design space was actually used in a coastal decision making context. Moreover, the effects of the co-design process on coastal management practice were limited, because the primary case study experiment was explicitly positioned as parallel to ongoing policy processes, and not directly linked.

The contribution of co-design activities to coastal management practice

In addition to the more elaborate primary case study, we also observed, analyzed and interpreted four collaborative activities in the coastal context: the secondary activities: Negril Bay Jamaica (A), Calculation norm for sediment nourishment on the Dutch coast (B), Core group meeting Scheldt Estuary (C), and the Slufter, Texel (D). These four collaborative activities relate to coastal management and aimed at collaboration between people from different backgrounds. All collaborative activities involved group deliberations in workshop settings as the primary 'platform'.

The collaborative activities were interpreted in terms of the theoretical promise of co-design. Comparing the secondary activities, we see that lack of appreciation of knowledge of the specific local context does indeed result in faults in the final design. For instance, these types of knowledge gaps occurred in the activity Negril Bay, Jamaica (A), when lack of insights in the local stakeholders' perspectives, as well as specialized expertise on coral reefs, resulted in incomplete solutions for a coastal management problem in Jamaica. Nevertheless, even in Activity A other learning effects occurred. For example, learning on the process aspects of the workshop, as well as the limits to the generalizability of nourishment strategies specific to the Dutch coast. Thus, we conclude that even when the outcomes of the collaborative activity are limited, learning effects still occur.

We learned that collaborative activities aimed at innovative coastal management solutions exist in the Dutch coastal management context, but specific co-design activities in this context are rare – especially co-design activities that address the social-ecological systems view. Despite the limitations of the empirical material we attempted to learn from activities that were collaborative and transdisciplinary in nature. In all cases, this led to knowledge sharing, and in several activities to solutions that can address different elements of the complex coastal system, including consideration of actor values, and social complexity. As such, co-design activities have the potential to identify a broader space in which solutions can exist, which we saw in the observed collaborative activities that occurred in idea-generation phases of design processes. Additionally, its knowledge creation potential resonates with the concept of participatory management and fits with current ideals in coastal management (e.g., ICM, Dutch Delta program). It supports the premise that solutions (partially) lie on the interface between natural, social, and governance systems, especially for complex problems for which we seek solutions with long-term societal benefits.

Strengthening the contribution of co-design activities to coastal management

Owing to the complexity and site-specific nature of coastal management problems, standard, processes for co-design cannot guarantee success. In this research, we argue that while the design of the site-specific co-design activities needs to be contextual, the process to be followed in designing and refining such activities is generic. The design principles were formulated to give a general direction for designing co-design activities in specific coastal management contexts.

These design principles for co-design activities are manifestations of the design variables that designers have at their disposal in designing a co-design activity. The design principles explicate the choices to be made when designing co-design activities, including: how knowledge from various sources is represented (P1, P2, P3, P4); choices regarding participant selection (P9); method choices (P11); phase of the design process, which is interknit with the purpose of the activity and its relation to the nested design process (P10); the ambition level for collaboration (P12); how trust issues are addressed (P6, P4); the scope of the problem, which is particularly problematic for the inherently dynamic coast, acknowledging the nested levels and scales (P5, P6, P7); reasons for initiating and doing co-design in the coastal context (P14). The design principles are particularly developed for the coastal context, but we expect that they are applicable in other problem contexts characterizable as complex systems. We invite other researchers to confirm or refute the design principles by applying them in other contexts.

#	Design principle
P1	Include local knowledge and local values
P2	Include scientific knowledge
P3	Facilitate knowledge sharing
P4	Give local community and experts equal voices and standing
P5	Account for contextual specificity and systemic complexity
P6	Appropriate scope
P7	Aim for transparency of relation with policy process
P8	Aim for transparent research
P9	Appropriate participant selection
P10	Appropriate moment of citizen involvement
P11	Strive for a creative level of engagement practice
P12	Strive for collaborative learning and building shared system understanding

The empirical research did not yield enough results to confirm the thirteenth design principle:

#	Design principle (unconfirmed)
P13	Avoid mismatch between rationale and goals (not confirmed)

We propose an additional fourteenth design principle, which was found in the empirical research:

#	Design principle (supplementary)
P14	Allow for adaptivity of the design of the activity to account for ongoing learning

In conclusion

This thesis describes the potential of co-design activities for addressing coastal management problems. The scientific contributions of the thesis include:

- A well-designed co-design process can potentially indeed meet the theoretical promise of co-design. We see this especially in the collaborative activities of the primary case study of south-western Texel, where depth of understanding of different subsystems and their coherence effectively encouraged design of solutions that encompassed institutions, policies and changes in the bio-geophysical landscape.
- The framework of analysis for co-design activities in the coastal context, which embodies a holistic way of conceptualizing reality underpinned by policy analysis, social-ecological systems thinking and transdisciplinarity.
- This framework of analysis also includes design principles and relevant design choices for designing co-design activities in the coastal context, as well as the theoretical promise of such activities.

- While limited, the empirical part of the research confirmed the expectations and assumptions on which the framework of analysis was based.
- The importance of iterative reflection (P14) was identified, which stresses the importance of adapting the design of the co-design activity to incorporate ongoing learning.
- This research identified that co-design in the Dutch coastal context is in its infancy. We were not able to observe ongoing co-design processes for coastal management strategies. This indicates that there is potential to further develop co-design in this context.
- That the craft in designing a co-design activity that delivers the promised outcomes lies in relating the relevant coastal context to the design of the activity.

Co-design provides a means of realising various ends. We observed, for instance, co-design activities with the goal of collaboratively designing engineering solutions to coastal problems. In other situations, the goals of the co-design activities were wider or were aimed at adapting policy. In general, we see that co-design activities aid in identifying (value) dilemmas, clarifying the diversity in actor perspectives, and broadening the potential space for solutions. Co-design activities ideally give different actors the room to work together in a creative and open manner. Local, scientific, practice-based and other forms of knowledge are ideally used in an egalitarian fashion in the search for solutions to coastal management problems. The thesis 'co-design in the coastal context' contributes to insights in how to design the co-design activities, reflects upon insights offered by a broad range of literature on co-design in complex systems, and offers usable and practical methods to evaluate such co-design activities.

CHAPTER 1

Introduction

The multi-actor and multi-disciplinary character of the coastal context implies that optimal solutions to coastal management challenges do not exist (B L M Kothuis & Kok, 2017; McEvoy, 2019; Rittel & Webber, 1973). Coastal management, especially in the Netherlands, has a tradition of stakeholder engagement in the development of decisions to ensure that solutions are socially acceptable. This gives rise to the question of how to balance stakeholder values and perspectives with scientific information and objectives when seeking effective solutions for coastal problems.

While there are many ways to include stakeholders, this dissertation specifically focuses on co-design activities: design-oriented, collaborative activities aimed at innovative coastal solutions. Leading to the research questions of this study, this chapter elaborates on collaboration in coastal management, on the complexity of coastal management problems, and on why this is important to research.

1.1. Collaboration in coastal management

To maintain the coast, to protect land against flooding from the sea, and to build infrastructures that provide a desired living environment now and in the future, the Netherlands knows intensive coastal management practices. The Netherlands is a low-lying delta, and approximately one-third of the country's land mass lies below mean sea level. The coastline is 350 km long, and densely populated, with between 9 and 10 million residents (out of 17.2 million) living in the coastal areas (Mulder et al., 2011; Stive et al., 2013). Sediment nourishments are necessary to prevent the Dutch coast from eroding. In addition, a vast infrastructural network of dikes, dams, sluices, pumps and sandy dunes protects the country against erosion and flooding from the sea. Without active management of this network, built over the course of centuries, the coast would erode and the low-lying parts of the Netherlands would eventually have to be given back to the sea (Mulder et al., 2011). Climate change, with its associated higher frequency of storm events and sea level rise, will exacerbate these problems (Slinger et al., 2020). For these reasons, Dutch coastal management is mostly a preventative endeavor against erosion and flooding.

The coastal zone serves an economic function, as approximately 65% of the Dutch GNP is generated in the coastal zone (Stive et al., 2013). The main coastal ecosystems, the North Sea, the Wadden Sea and the rivers and estuaries are ecologically rich, in part due to variation in conditions such as moisture, salinity, micro climate, and topography (Waterman et al., 1998). The coastal zone also serves an ecological function, exhibiting a wide range of habitats. Areas with exceptional biodiversity characterize the coast of the Netherlands and large parts of the coastal and marine ecosystems are nature reserves, covered under nature conservation laws and networks. The Wadden Sea is a UNESCO World Heritage site, and the Kennemer dunes, and the Dunes of Texel are examples of coastal national parks with a flood defense function protected under nature conservation laws. Aside from safety, economy and nature functions, coastal areas also deliver services such as (but not limited to) agriculture, fishery, recreation and tourism, culture and history (Waterman, 2010). This means that there is a societal drive to maintain the coastline position using sand nourishments for coastal functions other than only coastal safety (Mulder et al., 2011). The concept of nourishing the coast with sandy nourishments to dynamically maintain its position is critical in this endeavor (Hermans et al., 2013).

Dutch coastal management has traditionally involved a process of collaboration between different social actors and decision-makers. One of the oldest forms of government in the Netherlands is the water boards, stemming from small conglomerations of landowners and farmers, who united forces and shared responsibilities to build, operate and maintain sluices, levees and dikes. Water boards are the government authorities responsible for water-related problems on a regional level. Eight of the twenty-one water boards are located along the coast and have responsibility for coastal management.

Coastal management in the Netherlands has undergone many changes over the years. Before the mid-1990's, coastal management was primarily a technocratic, top-down affair. As such, standards for coastal flood protection as well as national flood management plans for the main rivers in the Netherlands date from the early 1960s, after the large storm surge of 1953 that inundated the South West area of Zeeland with water, and caused over 1800 fatalities (Kabat et al., 2009). Flood management took precedence over other issues and was mainly implemented by Rijkswaterstaat, the administrative and executive body of the Ministry of Infrastructure and the Environment (Cuppen, 2012, p. 2). However, public protests against large infrastructural changes, such as the plan to completely enclose the Eastern Scheldt, as well as near-flooding events in the 1990s and before the mid-2000s, incentivized the Dutch government to shift their flood management approach to take spatial, ecological and stakeholder values into account (Cuppen, 2012). As such, in the last few decades, coastal management in the Netherlands has shifted towards more public engagement in coastal decision-making. Today, coastal management policies, operational plans, strategies and laws have embraced public participation (Taljaard, 2011). Currently, in dealing with coastal threats, decision makers look for solutions that take technical, applied ecological, legal, political, social, and policy issues into account.

In conclusion, coastal management in the Netherlands provides unique contextual conditions. Actors exhibit a willingness to try out new ways to improve coastal management practice, as exemplified by the frequent use of pilot projects (Bontje, 2017; Vreugdenhil, 2010). The Netherlands is a world leader in coastal management practice, owing to a combination of necessity, low elevation, high urbanization in the coastal zone, and a longstanding, consensus seeking style of governance, involving

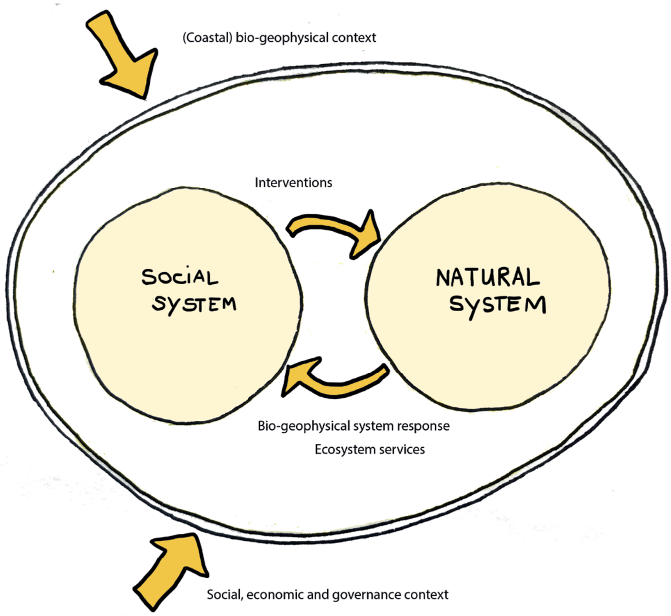


Figure 1-1 Illustrative and simplified conceptualization of a coastal system comprising of interconnected social and natural (sub) systems.

citizen consultation in politics and spatial planning. Additionally, the Netherlands is a Western democracy with a legal and regulatory framework for decision making which also takes social and ecological factors into account, and rests upon technical expertise and data-rich conditions.

1.2. The complexity of coastal management

The multi-faceted nature of coastal management, means that it can be considered a 'messy' or 'wicked' problem (cf. Ackoff, 1979; De Bruijn & Herder, 2009; Durant & Legge, 2006). Wicked problems are ill-defined, their solutions are subject to political judgment, and the multiplicity of their interlinked underlying issues make them complex (Rittel & Webber, 1973).

For this research, we lean on a background in systems thinking to conceptualize coastal management problems as complex systems, as illustrated in Figure 1-1 (cf. Ackoff, 1979; Checkland, 2000; Folke et al. 2005; Redman el al., 2004; F)

The complexity of coastal management problems stems from a number of key characteristics:

Multi-actor complexity. A variety of actors are characteristically involved in coastal systems, including citizens, interest groups, engineers, and decision makers. They often have different perspectives, competing interests and are interdependent, with unequal decision making power (Costanza et al., 1997; De Bruijn & Herder, 2009; Farber et al., 2002).

Multi-disciplinary character. Knowledge for addressing wicked coastal problems is situated in different disciplines, and requires increasing levels of interdisciplinary integration and collaboration (Freeman, 2000; Slinger et al., 2020; Tromp, 2019).

Spatial boundary problems. Coastal systems have no clear spatial boundaries, and if they do, they often conflict with other (institutional) boundaries. Additionally, bio-geophysical effects occurring within a system, usually affect neighboring or overarching systems and vice versa.

Temporal dynamics. The coastal environment is highly dynamic. Both the social environment, with its actor networks, and particularly the natural system which change over various temporal scales, and over short and long terms.

Uncertainty. There is inherent uncertainty and an abundance of ambiguous information on the coastal system and its future developments, such as the rate of sea level rise and the effects of climate change.

Institutional complexity. Institutions (i.e., any formal or informal rule, law, or custom) add to the complexity of coastal problems. Typically, the institutions are slower to change than the systems they are governing (Koppenjan & Groenewegen, 2005; Williamson, 1998). Finances and responsibilities for coastal functions are fragmented over different governmental authorities, where they ought to be involved together (Geest et al., 2008; Lubbers et al., 2007; Mulder et al., 2011; Taljaard et al., 2013).

Ethical complexity. A multi-actor environment exhibits diversity in moral considerations and judgments on what is right and wrong. But even in a complex system with 'full information' and 'zero uncertainty', conflicting moral judgments exist and develop, especially in regard to the natural environment and related long-term decision-making. Actors value moral principles differently.

1.3. Object of study: co-design activities

The multi-faceted and multi-actor character of the complex coastal context implies that optimal solutions do not exist, and solutions are negotiated (Kothuis & Kok, 2017; McEvoy, 2019; Rittel & Webber, 1973). Collaboration between citizens, researchers, scientists and other experts in coastal management is therefore necessary to find solutions that are societally acceptable and technically viable. The challenge lies in balancing actor values and perspectives with knowledge from different scientific disciplines when seeking effective solutions for coastal problems.

Within this complex coastal context, participatory activities that aim for collaboration between multiple actors to enrich the decision-making process occur. Indeed, current coastal management practice in the Netherlands is characterized by participation. This fits well with the field of Integrated Coastal Management, in which stakeholder engagement forms an intrinsic element. These participatory activities hide under a plethora of terms, such as: participation, knowledge co-creation, collaboration, stakeholder engagement, stakeholder involvement, joint fact-finding and more.

While participatory applications in practice are numerous, few of them address the design processes, nor the earlier stages of idea generation. Even with the strong tradition of participation in Dutch coastal management, designing *with* local actors is not recognized in this field, and scientific knowledge that prescribes how to undertake these activities is lacking. With the growing emphasis on research and application of such citizen engagement methods in coastal and environmental management (e.g., Reed, 2008; Von Korff et al., 2010), we choose to investigate design-oriented, collaborative activities aimed at new coastal solutions at diverse spatial and temporal scales.

In this research, we will therefore pay attention to the phenomenon of 'co-design' - a term used in (participatory) design research and practice - and we will explore the applicability of co-design in the complex coastal context.

Here, we use co-design in a broader sense to refer to designers, engineers, and people not necessarily trained in design practice working together in a process aimed at creating innovative solutions (see also Sanders & Stappers, 2008). Figure 1-2 illustrates the degrees of freedom and ambiguity in different phases of co-designing for coastal solutions (see also McEvoy, 2019). Each of the phases in such a process can potentially be collaborative or involve public participation. However, co-design activities can contribute most notably at the 'fuzzy front end', which is the most ambiguous and chaotic phase (Sanders & Stappers, 2008), and involves the development of criteria and idea generation (Figure 1-2). In co-design practice, this fuzzy front end grows as designers move closer to the future users of their designs (Sanders & Stappers, 2008). We note that in some instances, co-design practice can threaten existing power structures by requiring decision makers to relinquish some control, owing to the larger role that (public) participants then have in defining, for instance, design criteria or generating ideas (Sanders & Stappers, 2008).

Collaborative processes that are focused on the design of solutions for coastal management problems seem to be a logical next step to be explored in Dutch coastal management. We distinguish five characteristics of co-design activities in the

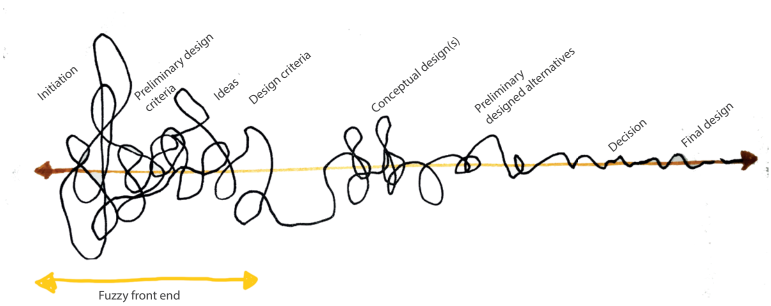


Figure 1-2 Illustration of co-designing coastal solutions, with more room for creativity at the front end of the process (adapted from Sanders & Stappers, 2008).

complex coastal management context. First, the creative activity of ‘designing’ as a way to collaborate and participate in an engaged manner is high on Sherry Arnstein’s ladder of participation and evokes citizen control, as opposed to citizen consultation or even manipulation (Arnstein, 1969). Second, such collaborative, design-oriented activities in a coastal management context often focus on the early stages of a design process, where there are more degrees of freedom for the eventual solution. Third, co-design incorporates collaboration between various domains and parties other than the conventional engineering or architectural domains in the design process, to achieve objectives that arise not only from the client, but also from the other actors in the coastal system. Fourth, co-design differs from conventional engineering design in that it considers more actors than the usual designer-client-user triangle. Fifth, we realize that co-designing solutions for wicked coastal management problems (such as a vision for a coastal nourishment strategy) involves a different emphasis on understanding the dynamics of the problem than co-design activities aimed at more straight-forward, user-oriented products.

1.4. Starting points for the research

This research project was formally initiated in a grant proposal to the Dutch Research Council (NWO) Here, key researchers hypothesized that a collaborative design approach provides an effective way to achieve early stakeholder support and a (provisional) best fit designed solution for a local coastal erosion problem for the Texel coast (Wijnberg et al., 2013). The research rationale explicated in the governance sub-project C[1] rests on a) the conviction that state-of-the-art scientific insights are required for effective solutions in dynamic coastal environments; b) a deep respect for local people and their knowledge, and the belief that local knowledge can be a valuable addition to the knowledge base; c) the conviction that the structured approaches of a policy analysis can deliver value in collaboration in complex decision making; d) a research role that lies between activism and engagement, seeking to enable society to change for the better (pers.comm. with Jill Slinger).

In this research, we therefore specifically turn to investigating design-oriented, collaborative activities aimed at innovative coastal solutions (co-design) and how they strengthen the development of solutions for coastal problems. We choose to investigate this in the context of Dutch coastal management, and we draw on the Dutch coastal management practice, the Dutch coastal management network, engineering expertise and models. The research investigates how to design these co-design activities in the context of coastal management, adopting a policy analytic perspective to account for the complexity of the coastal system, and the wickedness of coastal management problems.

1.5. Research objective and questions

The complexity of coastal management problems has contributed to the need for improved participatory support for coastal policy making. This research investigates

1 Sub-project C on the governance and multi-actor system is named ‘Co-Designing Nature-based interventions in Coastal Systems’ (Wijnberg et al., 2013).

whether collaborative, design-oriented activities can strengthen the development of solutions for coastal problems. Therefore, the general objective of the research is to *understand how to design and strengthen co-design activities in a coastal management context.* Here, we adopt a broad definition of the term 'co-design activity' as a specific, collaborative, design-oriented effort, delineated in time and scope.

This research objective leads to the following research questions.

> RQ 1: What is co-design?
>
> RQ 2: What does theory say about the promise of co-design activities, and about how this can be realized in a coastal management context?
>
> RQ 3: How do co-design activities contribute to coastal management in practice?
>
> RQ 4: How can the contribution of co-design activities to coastal management be strengthened?

To answer the RQs, we make the following methodological choices, described in more detail in Chapter 3:

- To consult literature in developing a definition of co-design, describing its theoretical promise for a coastal management context, and in exploring how to design co-design activities.
- To design, apply and observe an experiment in the form of a series of co-design activities for a coastal management problem, forming the primary case study.
- To observe other co-design activities that occur in a coastal management context, forming the secondary activities.
- To undertake a comparative analysis to distill lessons.

1.6. Research scope

An in-depth design and analysis of a series of co-design activities in Texel, the Netherlands will be undertaken for the primary case study research. Additionally, examples of other activities that contain elements of collaboration form the secondary activities. Each of the secondary activities take place within the network of Dutch coastal management practitioners are aimed at supporting coastal management problems. Again, we focus on Dutch coastal management practice, drawing heavily on Dutch engineering expertise and models. This forms a bias in the thesis.

Although participatory processes inherently come with learning by participants, we do not focus on psychological theory about learning, and instead lean on bodies of knowledge on participation within environmental studies. Although we touch upon the link between democracy and participation, this research does not have a political science, philosophy or sociology focus. We do not study value ethics or the fields of value-based engineering and design in depth, even though the local values of participating citizens are considered. We do not research ecological, biotic, or abiotic processes and how to influence them. Instead, we focus on the broader governance of coastal systems and how this can be supported through innovative co-design.

1.7. Reading guide

This dissertation consists of three parts: 1) theoretical analysis, 2) an analysis of practice and 3) the synthesis, conclusions and reflection. Figure 1-3 depicts the research structure. A reader can choose to read the sections of interest to them:

- For practitioners interested in the Dutch coast: Chapter 1, Chapter 4, Chapter 5, Chapter 6, Chapter 7
- For practitioners interested in prescriptive guidelines for co-design practice: Chapter 2, Chapter 7
- For researchers interested in methods: Chapter 3
- For researchers and practitioners interested in the theoretical promise of co-design: Chapter 2, Chapter 7
- For researchers interested in the theoretical framing and the literature review: Chapter 1, Chapter 2
- For researchers interested in the implications of the research: Chapter 1, Chapter 7

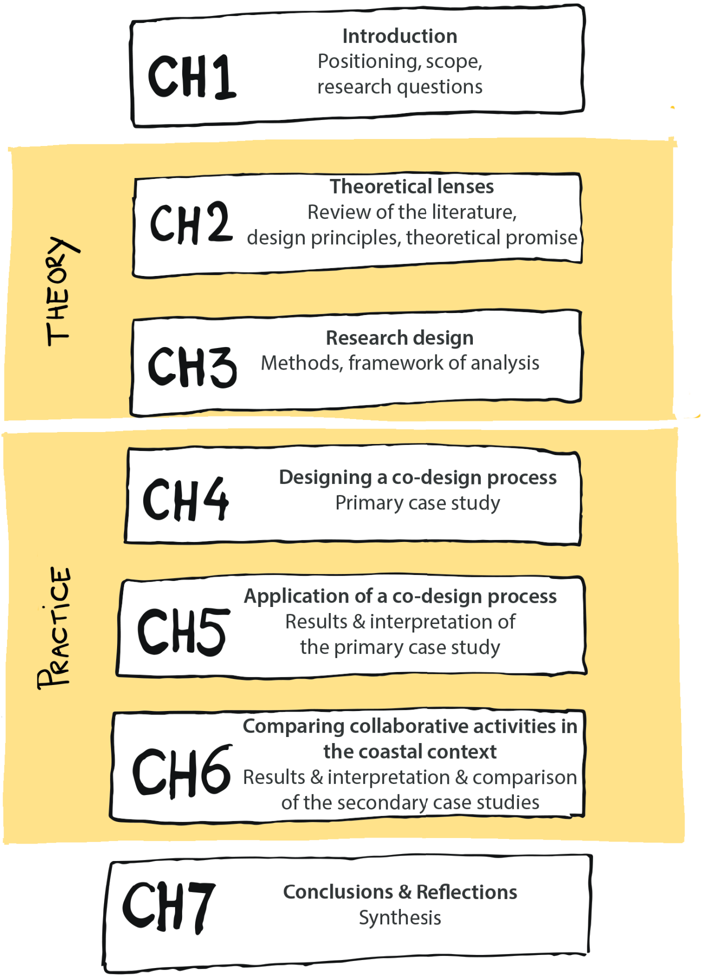


Figure 1-3 Structure of the dissertation

CHAPTER 2
Theoretical lenses

In this chapter, we consult scientific bodies of literature to build a comprehensive understanding of co-design in the coastal context, by studying manifestations of participation, collaboration and multi-actor interactions. For this, we move away from *loci* specific to the coastal context, and turn to research fields engaged in solving 'real-world problems' for which society requires integrated solutions:

- Policy analysis and more specifically, participatory policy analysis.
- Participatory methods in an environmental context.
- Participatory studies focusing on specific coast or coastal systems, as well as studies on water management, which are not always grounded in the physical environment, but contribute insights on interactions between technology and society.
- Engineering and engineering design, the generic field of research and application of creative problem-solving processes, where solutions are found by creative application of science, mathematics, and empirical evidence. Engineering cannot be separated from the coastal context, because engineering expertise is at the core of coastal management plans in the Netherlands.
- Co-engineering in water management, a specific framework with overlap to the problem situation of this current research.
- The field of participatory design, and participatory design research, which comes from a relatively small science community which applies and researches combinations of design methods and forms of citizen participation.
- Transdisciplinary research, which will give us insights on for instance the commonalities and differences between collaboration and participation.

We rely on learning from scientific literature to define co-design (RQ1). The literature study delivers insights in the theoretical promise of co-design and, later, forms the foundation for the design principles (RQ2), which are later used to analyze and compare observations.

2.1. Participatory policy analysis and its role in coastal management

Considering the emphasis of this research, understanding co-design activities specific to policy making in the coastal context, we first describe policy analysis. This section elaborates on the definition of policy analysis, some background and policy analysis styles. Finally, we argue for the appropriateness of a participatory style of policy analysis in this research.

2.1.1. What is policy analysis?

Policy analysis is a field of study, separated from the actual policy-making processes, that aims to support policy makers and enlighten policy discussions through analysis. The field of policy analysis emphasizes the structured collection, interpretation and communication of information related to policy issues, and typically considers complex systems and wicked problems (Dunn, 2003; Enserink et al., 2010; Miser &

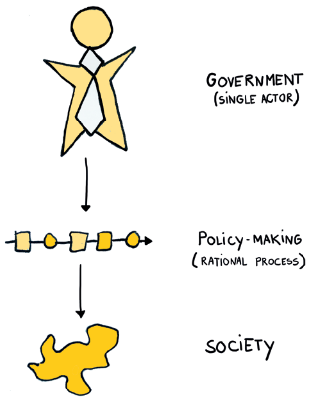


Figure 2-1 Top-down, single actor policy making

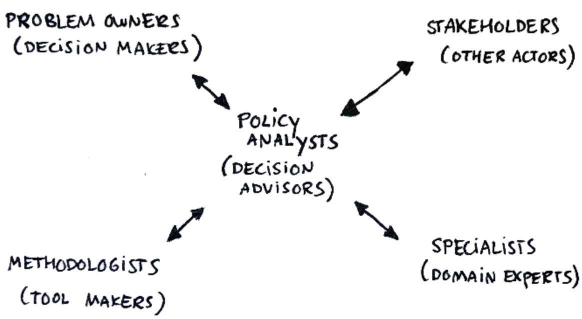


Figure 2-2 Policy analysis in a multi-actor network

Quade, 1985; Monnikhof, 2006; Thissen & Twaalfhoven, 2001; Thissen & Walker, 2013). Although most of the work in the field of policy analysis describes normative visions on policy analysis and on the development of methods and tools, attention is also paid to systematic evaluation of policy analytic activities (e.g., Thissen & Twaalfhoven, 2001).

Policy analysis originated in the United States of America in the 20th century, and was introduced in Western Europe in the 1970s. Originally, policy analysis was part of the field of operations research, and was used for military planning (Wildavsky, 1966). In the early days, policy analysis was often referred to as 'systems analysis' and had a technocratic character. This fits with the view that policy making was done by a single actor, the government, in a linear and rational way for the benefit of society (Figure 2-1). Policy analysis aided the policy making process by providing the government with the 'best' or 'most optimal' solution for specific problems (Hermans, 2005; Karstens et al., 2007). Models and tools were often used to provide supportive argumentation and analysis of the quality of solutions.

But in reality, policy making is not a rational and linear process. It is iterative and indeed can be chaotic, incremental and sometimes irrational. This realization found traction among policy scientists. Lindblom (2018) coined the term 'muddling through' to describe the incremental and incomprehensive reality of the policy making process. Decisions made in this policy making process often failed due to lack of support from actors involved in the implementation (De Bruijn & Herder, 2009; Thissen & Walker, 2013), or through outright public obstruction of decisions (Enserink et al., 2010). Figure 2-2 illustrates the role of the policy analyst in a multi-actor network in a simplified way, which is characterized by interactions in a network of actors. The recognition of the non-linearity and the dynamic multi-actor character of policy making processes gave rise to the development of new forms of decision making, including participative and interactive ways of decision making (Karstens, 2009).

The shift from single-actor policy making to multi-actor policy making came with a shift towards subjective rationality (Kørnøv & Thissen, 2000; Van de Riet, 2003). The multi-actor perspective acknowledges the presence of multiple actors within a decision making process, holding (conflicting) interests, perspectives and objectives on a problem situation. It follows that there is no single, best and true solution to a problem situation. Instead, it depends who a policy maker asks for input. Therefore, and for interdependencies between actors, policy makers have no choice but to include actors with decision making power and resources (including knowledge) in the policy making process. This process is characterized by involved actors who are mutually dependent, who have to cooperate to realize a policy, and interaction between these actors determines the system outcome (Van de Riet, 2003). Additionally, information in the process is often incomplete and contested (De Bruijn & Herder, 2009).

Recognition of the multi-actor environment has given rise to a demand for ways to include actors in the policy making process. Policy analysis has developed methods, theories and concepts to address policy problems that involve actors organized in networks, where actors are interrelated in a more or less systemic way, and strategic behavior and (collective) learning occurs among actors. Problem structuring, game theory, action research, and other research fields and practices came to be the foundation for such policy analysis methods. Complexity in such environments is added through these actor networks, and in meta-networks or 'networks of networks', where the same actors have relational dependencies in multiple 'actor arena's' on different issues (De Bruijn & Herder, 2009). One problem in such situations, is that these multi-actor networks involve people with varying abilities to articulate, and diverse degrees of knowledge (Hermans, 2008; Scharpf, 1973).

The field of policy analysis has developed into a broad field in which different styles of policy analysis are possible. Mayer et al. (2004) developed a framework that recognizes six clusters of policy analytical activities: research and analyze; design and recommend; clarify arguments and values; provide strategic advice; democratize; and mediate (Mayer et al., 2004). In addition, Mayer et al. (2004) built upon these activities by associating them with six archetypical styles distilled from literature: a rational style; an argumentative style; a client advice style; a participatory style; a process style; and an interactive style (Figure 2-3).

In Mayer et al (2004), the participatory style of policy analysis is defined as a field that looks at society critically. Not all parts of a society have equal access to policy systems (Fischer & Pellow, 2002). Hence, policy decisions and discussion are dominated by the groups of people with more access, and thus more power: actors such as economic elites, politicians, institutionalized non-governmental organizations (NGOs), or governance agencies (Mayer et al., 2004). Policy makers, researchers and engineers can exercise power as their positions and roles shift within a system. Conversely, certain groups of people are repeatedly excluded from policy

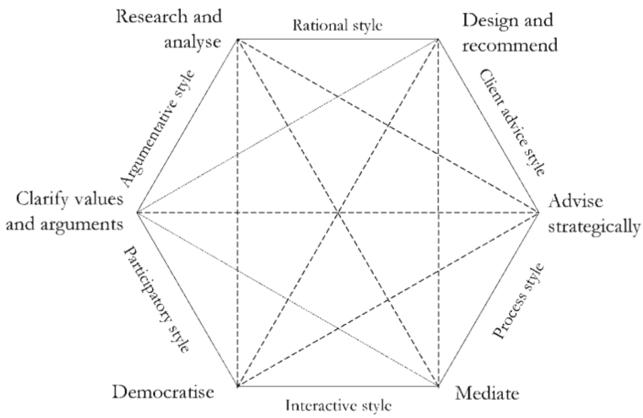


Figure 2-3 Hexagon Model: an overview of activities that make up policy analysis at the vertices, and the associated styles of a policy analyst on the edges (Mayer et al., 2004).

debates, and their issues are less likely to make the policy agenda. Such groups are referred to as marginalized groups, citizens, communities, local people, people on the fringes of society, depending on the subject and the research field. Participatory policy analysis views the knowledge of these marginalized groups as valuable, and activities that facilitate their inclusion in the policy debate in a substantive way. Underlying the participatory policy analysis view are values such as equality, citizen empowerment, and democratization. This is in line with this research, as it fits with the aim to include local knowledge to enrich policy design. Accordingly, whether certain groups of people have been in- or excluded from policy debates is a key reason and consideration for doing participatory case study research. In addition to the participatory style of policy analysis, other styles are also relevant to and present in co-design activities. Values and arguments that exist in the actor network can be elicited and clarified through collaborative design activities, and co-design activities show also promise for mediation and strategic advice, and as such, fit with the process and interactive styles, as we will see in the empirical part of this research.

2.1.2. Participatory policy analysis in coastal management

The complexity of coastal systems stems from socio-economic, environmental and institutional, and technological subsystems, and their interrelations. We also know that the current style of decision-making on coasts, or coastal management as a theory field, has embraced participation (Taljaard, 2011; Taljaard et al., 2013; Taljaard, Slinger, Morant, et al., 2012).

Numerous examples of participatory studies exist, - theories, - tools and - methods, among which are: participative modeling (Geurts & Joldersma, 2001)

There exist countless examples of participatory studies, - theories, - tools and - methods, among which are: participative modeling (Geurts & Joldersma, 2001), tools to support participatory adaptive planning workshops (McEvoy et al., 2018, 2019), system dynamics modeling (Andersen et al., 1997; Rouwette, 2012; Stave, 2002; Vennix, 1999), mediated modeling (e.g., Metcalf et al., 2010), participatory agent based social simulation (Pahl-Wostl & Hare, 2004), and participatory serious games (Gomes et al., 2018).

For the coastal context specifically, and the water management context more broadly, we were especially inspired by the following studies. To know how to manage water and coastal systems as a decision maker, you have to know what the important issues are. Jai Clifford-Holmes (2015), who did a stakeholder engagement modeling process that revealed deep system knowledge held by local stakeholders. This stakeholder knowledge proved to be crucial for understanding the water system and would not have been accessible for decision-makers if it not were for the stakeholder engagement process. Similar findings come from a system dynamics modeling context (Kallis et al., 2006; Stave, 2002). Additionally, case studies on the Groot Brak Estuary in South Africa have focused on participatory processes, stakeholder engagement and local knowledge (Slinger et al., 2005; Taljaard, 2011; Taljaard, Slinger, Huizinga, et al., 2012). Additional international exemplars of management of estuaries have provided insights in transdisciplinarity in such complex and diverse coastal contexts (Slinger et al., 2020). Some of these benefits and other reasons for doing participatory work are further explored in the next section.

2.1.3. Rationales for choosing participation in environmental management

Over the last few decades, many review articles highlight the benefits of participation in governance issues (Arnstein, 1969; De Bruijn & Herder, 2009; Enserink et al., 2010; Koppenjan & Groenewegen, 2005; Mayer et al., 2004; Morinville & Harris, 2014; Reed, 2008; Stave, 2010; Taljaard, Slinger, Morant, et al., 2012). As discussed in Section 2.1.1. on policy analysis, the fact that decision making power is spread out between actors invokes collaboration and multi-actor decision making. Other important reasons to involve stakeholders in decision making in the school of policy analysis are the importance of the democratic character of decision making, enhanced support or less oppositions for policy proposals, and a higher quality of policy outcomes (Edelenbos & Klijn, 2006).

In his extensive literature review, Reed (2008) addresses stakeholder participation in environmental management, and examines evidence for claims made for, and against, participation. Reed recognizes that participation in environmental management is no panacea and describes arguments deriving from different lines of reasoning. On the one hand, value-related reasoning perceives participation as a 'democratic right' (Martin & Sherington, 1997); it enables 'empowerment' (Greenwood et al., 1993; Macnaghten & Jacobs, 1997; Okali et al., 1994; Wallerstein, 1999); it increases equity and decreases marginalization of those in the periphery of the decision-making context (Morinville & Harris, 2014; Reed et al., 2010). On the other hand, more pragmatic lines of argument focus on the quality, durability and feasibility of decisions that were made through stakeholder engagement (e.g., participation enables interventions to be better adapted to local environmental conditions) (Beierle, 2002; Richardson & Pugh III, 1981; Rowe & Frewer, 2000). Overall, a wide array of benefits from participation are described in the literature.

Table 2-1 Idealistic and pragmatic lines of reasoning, which are used to analyses claims for participatory benefits

Type of rationale	Considerations	Examples of answers to the question: why should we do participation?
Idealistic	Values	"Because participation is inherently democratic."
	Norms	"Because we need methods that equalize power between participants."
Pragmatic	Purposive considerations	"Because early participation will lead to less opposition, and thus less costs, when implementing the chosen solution." "Because it improves the inherent quality of the outcome." "Because it is legally required: "we have to do it".
	Empirical considerations	"Because we have evidence of success of such methods under particular circumstances."

In the following analysis of the literature (Table 2-1), we distinguish two categories: idealistic and pragmatic lines of reasoning. The idealistic category encompasses norms and values, and relates to the questions *'what should we do?,' 'what is it we want to achieve?'*, or *'how should we do what we want to do?'* (adapted from Max-Neef, 2005). An example of such a value is to act to embrace democratic ideals, which in democratic societies is usually answered by democratic tools such as voting, or assessment approaches such as environmental impact assessment, that originated as a normative response to growing traction from the environmental movement. Alternatively, pragmatic lines of reasoning relate to the questions 'what are we capable of doing?, or 'what relationships exist'. Examples of pragmatic types of reasoning is to do stakeholder engagement workshops because that will lead to less opposition, and thus less costs at a later stage when implementing the chosen solution.

Identifying rationales remains difficult, especially when these are not explicitly stated by initiators of a participatory project, or when the rationale appears muddled. An interesting example of a muddled rationale is provided by a stakeholder engagement process executed because it is required by law. While such a law (e.g., Waterwet, 2009 in the Netherlands) has been written in the spirit of democratizing, this value may not be shared at the operational level where the stakeholder engagement process must be executed Here, keeping to the letter of the law is rooted in pragmatism, i.e., '*we do it because we must*'. In this example, the nested nature of environmental management problems makes it difficult to specify the rationale for complexity.

Three observations are derived from the broad cross-comparison of the underlying rationale for choosing a participatory approach in selected literature on public participation in the field of environmental management. A summary of these findings is presented in Table A1 in Appendix A.

First, the claimed benefits of participation are not always fully substantiated by empirical research (Newig & Fritsch, 2009; Reed, 2008). Claims for the participation panacea are not always warranted (Morinville & Harris, 2014; Newig & Fritsch, 2009; Reed, 2008). Longitudinal studies with predominant anthropological and sociological perspectives support claims of the long-term effects of engagement with policy makers and local stakeholders (Devlin & Yap, 2008; O'Faircheallaigh, 2010). For project-based studies with a shorter time horizons, unsubstantiated promises of the benefits of proposed participatory processes are found, which may lead to disappointment and distrust on the part of both stakeholders and policy makers in the longer term (Cuppen, 2012; Newig & Fritsch, 2009; Reed, 2008).

Second, from a governance perspective, the benefits of participatory policy-making processes for governments are usually described in terms of normative objectives, such as building better policy decisions, avoiding litigation, gaining legitimacy, educating stakeholders and building trust and strategic alliances (Irvin & Stansbury, 2004). Such claimed benefits are used to justify choosing for participation and stakeholder engagement. However, the choice for participation happens earlier, and appears to lie more on the value-related level, linked to democratic ideals, equity and empowerment. Implicit assumptions that participatory decision-making will be more sustainable, that it can foster social learning and insights in non-scientific fields, or that it reflects other pragmatic considerations because there is more support and funding for participatory (research) projects in recent decades owing to the positive image of participation (Reed, 2008; Stringer et al., 2006). There is evidently an (implicit) discrepancy between the rationale for choosing participation and the outcome-driven objectives underlying this choice.

Finally, when describing participatory approaches in (environmental) management situations, people use different kinds of (pro and con) claims, reasons and evidence (Booth et al., 2008; Toulmin et al., 1979). Where some emphasize implicitly or explicitly that participation is an imperative, not necessarily because it can lead to democracy, but because it inherently is democracy (Arnstein, 1969; Habermas, 1987; Morinville & Harris, 2014), others focus on the potential for participation to be a useful tool towards more democracy and transparency (Agarwal, 2001, 2010; Blackstock et al., 2007; Greenwood et al., 1993; Landry et al., 2003; Macnaghten & Jacobs, 1997; Okali et al., 1994; Richards et al., 2004; Wallerstein, 1999). These strands of thinking underline the distinction between democratic principles and democratic practice.

In conclusion, the underlying rationale for choosing a participatory style of project management is not always explicated nor is it warranted, although it cannot be denied that the positive image of participation, its visibility and marketability, and its association with democratic ideals give the approach political traction. For this research, we are satisfied with the notion that participatory projects and activities that are in some way linked to the coastal policy making process, are often unclear and muddled. Especially when multiple actors are involved – as is almost always the case – participation may be welcomed by the initiators and organizers of a process as a solution for everything by all involved, but for different reasons. Enquiry as to the reasons is therefore warranted as methods and rationales for applying them should align. However, it remains doubtful that claims and underlying rationales are explicated and clear when participatory approaches are implemented.

2.2. Collaboration and participation in design and engineering design

2.2.1. The convoluted nature of terms associated with design

Design science in general, and engineering design science specifically, focuses on the process of designing (Dym & Levitt, 1991; Dym & Little, 2004; Eggert, 2005; Ertas & Jones, 1993; Hubka & Eder, 2012).

There are many different definitions of design, both in scientific language and in common parlance. The term 'design' can refer to a verb and a noun. According to the Oxford Dictionary (2nd edition), the noun 'design' refers to the detailed description of an object in a certain formalism (e.g., a blueprint, or a detailed drawing of a building), and the verb 'to design' refers to the action of deciding upon the look and functioning of an object. Here, for clarity, we use the term 'design process' to refer to

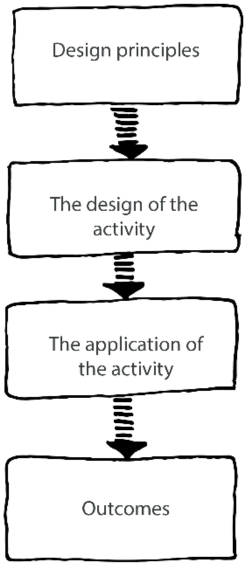


Figure 2-4 Conceptual structure to entangle the different meanings of 'design'. The figure represents stratification of a conceptual, multi-level design environment.

the actions to take to decide upon the look and functioning of an artefact (the verb). Here, the term 'process' simply refers to a series of actions, and 'the design' refers to the noun.

Figure 2-4 offers a visual representation of the stratification of a conceptual, multi-level design environment. This multi-level notion is borrowed from the field of computer science and simulation modeling, which also deals with complex systems that are characterized by a large number of diverse components, and interdisciplinary teams that collaborate on the development of the same system (Vangheluwe & De Lara, 2002).

The visual representation of Figure 2-4 illustrates the different ways in and conceptual levels on which the term 'design' can be understood, specified to this research. The highest box indicates a meta-level to inform the design of the activity. In this research, these take on the form of design principles (see also 2.4.5.), which in turn prescribe the application of the activity. (These design principles are specific to this research, and thus differ from possible other design principles, i.e. technical requirements for design). Then, the outcomes follow from the activity. Contextual input affects choices in each level. In this research, the application of the activity refers to a co-design activity. The outcomes of the co-design activity include 'co-designs', or co-designed solutions.

The stratification of design and Figure 2-4 indicate a few things. First, abundant use of the term 'design' can lead to misuse and misunderstanding, especially in interdisciplinary research where the risk of miscommunication is high. Second, Figure 2-4 is neither a chronological, nor normative prescription of how to go about designing. Additionally, we see that some designers start the design process on the lower levels of Figure 2-4, and 'learn through designing'. Other design processes start at the higher, more theoretical levels of Figure 2-4 . Third, iterative feedback exists in the form of interaction between actions and products on each level. Typically, in a design process changes are made to the final product through adaptation and iteration (Dym & Little, 2004).

The structure of Figure 2-4 aims to clarify the different elements that are important for designing in collaboration for the coastal context. For the purpose of this research, which included investigating how to design co-design for a coastal management context, a design on a meta-level is useful to identify the necessity of a generic structure for a co-design activity in the coastal management context. We realize that when we, as researchers, involve other participants in a process that is directed at designing solutions for coastal management problems, our objective is to create environments that allow for those participants to be creative (G. Fischer & Scharff, 2000).This task is vastly different than actually designing ourselves. So, investigating what those environments should look like relates to our research objective to investigate how to design co-design activities in a coastal management context.

2.2.2. Engineering design

Engineering is often seen as a problem-solving process, a creative one, where solutions are found by creative application of science, mathematics, and empirical evidence. Just as for design, there are also many definitions for the word 'engineering' (e.g., Dym & Levitt, 1991; Dym & Little, 2004; Eggert, 2005; Ertas & Jones, 1993). Most of the definitions agree that the goal of engineering is to find solutions for the benefit of mankind (Daniell, 2012). The link between technology and society is also emphasized by the Royal Netherlands Society of Engineers (KIVI-NIRIA). In their Code of Ethics, they underline safety and health, of society and the environment, as well as rigor, transparency, openness, and respect for cultural values and individuals.

A distinguishing characteristic of engineering design is the final product. Where in other domains (e.g., graphic design) the designer actually produces the final artefact, in engineering design, the end product is the design documentation, i.e., a set of specifications for producing the artefact, and not the artefact itself (Dym & Little, 2004). As such, a major factor in engineering design is developing ways to describe these specifications clearly and unambiguously. Although engineering disciplines are stereotypically associated with the physical world of technology, such as mechanical engineering, civil engineering or aerospace engineering, engineering can also arrive at non-physical solutions, e.g., decision engineering (March, 1978)and guesses about future preferences for those consequences (Savage, 1954; Thompson, 1967. An additional characteristic specific to the coastal context, is that engineers tend to consider functionality, and on other requirements influencing the design choices. For example, civil engineers focus on robust solutions, and hydraulic and coastal engineers want their engineering designs to meet coastal safety standards (Vreugdenhil et al., 2010). Current trends in coastal management move towards multi-functionality of flood defense infrastructures (Tromp, 2019).

An overlapping concept for engineering design processes is that they are systematic processes, consisting of a number of steps or 'phases', to get from a complex problem in the messy real world to functional specifications of an artefact (i.e., in terms of 'meta-design'). Objectives, needs and constraints come from actors such as the clients and sometimes the user. The phases are defined in various ways, but generally are structured to address the problem definition by considering relevant information, and the generation and analysis of alternatives, followed by evaluation. The iterative nature of the engineering design process is always emphasized (Dym & Levitt, 1991; Dym & Little, 2004; Eggert, 2005; Ertas & Jones, 1993; Hubka & Eder, 2012; Voorendt, 2015), similarly to other design fields.

2.2.3. Co-engineering in water management

There exists a trend to have engineering move towards more participation so as to support the development of well-structured dialogues between stakeholders, decision-makers and scientists. One of the ways to form such dialogues is through co-engineering in water management, where 'co-engineering' refers to deciding upon how 'forms of collective action to support water management are themselves engineered by internal or external agents to the management system' (Daniell, 2012, p. 51). As such, Daniell argues here for considering to making both the stakeholder engagement process and the engineering process participatory.

Additionally, co-engineering in water management allows for various levels of participation, including public participation, during an engineering process. Co-engineering is further specified into the phases co-initiation, co-design and co-implementation, and each of these phases have particular roles and tasks for various (public) participants (Daniell, 2012). The first phase 'co-initiation' includes the participatory process organizers, typically a team of experts who decide *together* on problem scope, methodologies, and resources. The second phase is done with a (possibly) other project team that decides upon the objectives, methods, participants and evaluation criteria. The co-design phase typically delivers a design for participatory structures that are best to deal with the problem at hand, which makes the entire co-engineering process very well-equipped to deal with high levels of contextualization. The third phase is co-implementation phase, with a project team that organizes, facilitates, models, analyses, evaluates and disseminates the research results.

The usefulness of Daniell's work on co-engineering in water management for this particular research project is especially notable through the similarity in world-view. Her focus lies on systems thinking and governance, trans- and interdisciplinary collaboration and participation in a water management context. The applicability of co-engineering in the water management context are similar this research. Additionally, the explicit recognition of the roles of people involved with the project and the separation of project phases, such as the inclusion of the initiation phase in the co-engineering entire process have implications for the evaluation of the co-engineering process as a whole. It is this stratification, i.e., collaboration on different levels characterizes this research. The concept of co-engineering helps to widen the scope of using co-design beyond designing an artefact, to include co-determination of goals, functioning and design criteria, in all phases of an engineering process, including the idea generation phase.

2.2.4. Participatory design research

One of the disciplines that uses the term 'participation' is the field of participatory design research. Participatory design research is a field of inquiry that investigates creative processes involving designers and people not trained in design. Similarly to policy analysis and some of the engineering disciplines, participatory design research focuses on the relationship between humans, technology, and design. In this field, the terms co-design and participatory design are closely related, and are sometimes convoluted.

A key principle of participatory design is that both the research and design work is done with the users (the people who will use the designed artefact), as opposed to on behalf of the users (Iivari in: Spinuzzi, 2005). Thus, participatory design involves approaches rooted in the tradition of design science, design thinking and design research. Additionally, integration occurs across academic disciplines and public policy areas, including participatory art, participatory action research, participatory democracy, participatory culture, and participatory journalism (Halskov & Hansen, 2015). Participatory design researchers study creative processes where designers and non-designers, citizens or users collaborate together. The designed artefacts are designed with community members and often offer solutions to improve the lives of these participants directly. Examples of such goals for workers include: less routine work, greater autonomy, or more effective tools. The forms of collaboration place requirements on the roles of designers, users and researchers, and moves away from a classical user-research-designer triangle (see also Figure 1-2.).

Participatory design allows for participation throughout the entire design- or decision-making process. Moreover, some of the literature takes the normative stance that participatory design should be inclusive of users throughout the entire process, from research to implementation (e.g., Spinuzzi, 2005; Szebeko & Tan, 2010). This inclusivity is reached through different tools and methods (Halskov & Hansen, 2015) Indeed, literature on participatory design emphasizes the need for 'full participation' as both a democratic aim in itself, and as a pragmatic effort to create better designs (Andersen et al., 2015). However, other authors take a less prescriptive stance, by acknowledging the different forms of participation exist at different times during a research project, and that this may or may not be participative at all times (e.g., Sanders & Stappers, 2008).

Participatory design rationalizes its choice to do user- or stakeholder-inclusive work with democratic idealism, as well as pragmatic realism. Participatory design is both a means to a better democracy, and a way to get a better designed solution. As such, the research extends beyond the more traditional, immediate research goals of interest. Indeed, the underlying value of this way of doing research has a clear political-ethical orientation, to empower participants (e.g., workers, users, stakeholders) (Ehn, 1989). By association, participatory designers see themselves as facilitators as opposed to dictators (Clement 1994). We can discern the underlying value of benefiting society through democratization by reflecting on the history of the research field. Participatory design originated in Scandinavia in the 1970s, and reflects Marxist and democratic idealism (Spinuzzi, 2005).

Consequently nowadays, participatory design's methodology leans on participatory action research methodology: practical, and interventionist investigation (as opposed to data gathering) and, parallel, theoretical reflection (Spinuzzi, 2005). Indeed, action research and participatory design share the overall goal that the aim of the research project should be to improve the participants' lives, either practically or politically. Published papers in the field of participatory design also lean on neighboring fields of inquiry, and build on theoretical foundations drawn from feminism, human-computer interaction, action research, and computer-supported cooperative work.

Participatory design is applicable to various problem contexts, and research on the applicability of participatory design in new fields is ongoing (Halskov & Hansen, 2015). However, problem situations for complex systems, where solutions involve changing the context, are unusual topics. Similarly, institutional requirements are seen external to the solution space. Participatory design for 'wicked' problems that allow for designing changes in the institutional and natural contexts is relatively new.

We recognize see the overlap between participatory design and participatory policy analysis styles (Section 2.1.), that also aims to include knowledge of the non-elite in the decision making process.

2.3. Transdisciplinary research and methods

Transdisciplinary research is a term that relates to terms such as multi-disciplinary, interdisciplinary, and pluri-disciplinary (Bergmann et al., 2012; Max-Neef, 2005). What 'transdisciplinary' is, is defined differently among authors. Here, we use transdisciplinary to refer to research projects that combine various types of knowledge, including but not limited to specialized scientific knowledge through a variety of methods, including collaboration and participation.

Indeed, participation is not the only form in which people from different backgrounds meet in coastal management. Collaboration between disciplines is required as well. The strong contextualization of coastal issues shapes research agendas and priorities, but also influences research methods and topics (Nowotny et al., 2001). In fact, the strong differentiation of scientific disciplines related to the coasts investigating ever more precisely particular aspects of reality. E.g., hydrodynamicists analyze and model the motion of coastal and tidal currents, waves and storm surges in the near-shore zone; hydrologists concentrate on the movement of the coastal waters; ecologists and biologists are concerned with flora and fauna in systems such as the sea, the foreshore, and the beach-dune systems; anthropologists study humans living in the coastal communities; civil engineers are tasked with developing infrastructures; spatial planners think about future resilience of coastal areas; ethicists ponder the morality of unequal flood risk for communities; et cetera. However, the specialized knowledge of any of these research fields can only deal with certain aspects of the problem.

These two tendencies, i.e., the progressive differentiation of science on the one hand, and the demand for integrated solutions to societal problems on the other (Bergmann et al., 2012), result in the need for integration within scientific practice.

In a transdisciplinary context, production of knowledge occurs along two innovation paths that interact. The practice-based path explores new options for solving societal problems and the scientific path commits to the development of interdisciplinary approaches and methods. As such, integration occurs at the level of the interface between scientific issues and societal problems (Bergmann et al., 2012). Case studies are place-based, and therefore contextualization is a characteristic in transdisciplinary research. Parallel production of knowledge is recognized in various (methodological) fields of research where the focus lies on these interfaces. Hevner et al. (2004) in their work on design science distinguishes between the environment and the knowledge base, where information systems are produced between these spaces. Here, the environment defines the problem space in which reside the factors of interest, and the knowledge base provides the foundations and methodologies of relevant interests through which the research is accomplished. Similarly, Mingers and Rosenhead's framework (Mingers & Rosenhead, 2001, 2004) for multi-methodology distinguishes between the problem content system, the intellectual resources system and the research system, that all interconnect in a non-hierarchical manner.

Different terms are used to make the distinction between knowledge sources. A main distinction is the difference between knowledge that belongs to the scientific discourse on the one hand, and societal discourse on the other hand (Bergmann et al., 2012; Jahn et al., 2012). Terms associated with knowledge about the societal context include: local knowledge (Cornwall & Jewkes, 1995; F. Fischer & Pellow, 2002; Slinger et al., 2007), local expertise (Hermans, 2005, 2008), real-world knowledge (Checkland, 2000), social knowledge (Bouwen & Taillieu, 2004; O'Faircheallaigh, 2010; Sadler, 2004). There are subtle differences in meanings and uses of these terms, but they all refer to the knowledge citizens have about their local environment. Depending on the study, these terms supplement the scientific knowledge bases, which is called disciplinary knowledge (Lattuca et al., 2013), scientific knowledge (e.g., Raymond et al., 2010; Slinger et al., 2005; Stringer et al., 2006; Thissen & Walker, 2013); technical knowledge (O'Faircheallaigh, 2010); or formal knowledge (Max-Neef, 2005; Mieg, 2006).

It should be noted that the (terms for) knowledge sources overlap. For instance, scientific discourse often describes societal discourse and vice versa. However, in transdisciplinary research knowledge is non-hierarchical: knowledge is considered equally valuable and useful in transdisciplinary research, whether the knowledge comes from local citizens or from the scientific knowledge base. In this research, we recognize different terminology across the observed collaborative activities, but we mainly refer to local knowledge and disciplinary knowledge in making a distinction where this is needed.

2.4. An understanding of co-design activities for coastal management problems

This chapter investigated the literature and described issues relating to participatory policy analysis, design, engineering design, and transdisciplinary research. In this concluding section, we untangle threads of co-design to expose its theoretical characteristics, which are used to define what co-design is (RQ1). Next, we describe the theoretical promise that co-design activities hold in a coastal management context and formulate design principles for the realization of the theoretical promise (RQ2).

2.4.1. Remarks on commonalities

In concluding the literature study, we use input from the different research fields to build our understanding of co-design. There are several lenses that can be used to understand at co-design in the coastal context better. As co-design is a fairly new concept, definitions of the term are still emerging. Despite some differences, we identify three commonalties.

A first common strand is design. The prefix 'co-'means 'with' or 'together'. Co-design can therefore be defined as a process of designing performed 'together' or 'with others'. For instance, the form of design could be collaborative, cooperative, (etc.). It is this collectivity, the nature of the social processes associated with engineering practice (Daniell, 2012), and the way they affect coastal management that are of interest. Where participation and collaboration have extensively been framed and studied in many aspects of the policy process, we now focus on the process of collaboratively designing, rather than only concentrating on the problem-solving aspects of a multi-party collaboration in coastal management (cf. Bouwen and Taillieu, 2004). This research is concerned with co-design in the coastal context and looks at collaborative and creative practices within a wider problem scope of coastal system complexity.

A second common strand is the compatibility of co-design and co-design activities with polycentric forms of governance. The shift from a top-down towards a more bottom-up approach in coastal management (Morinville & Harris, 2014; Reed et al., 2010; Taljaard et al., 2013) refers to situations where multiple centers of decision-making co-exist that are all connected through shared institutional settings (Biesbroek, 2014; Ostrom, 2010). However, compared with other forms of participation, co-design aims to involve stakeholders in the early stages of the decision-making process, or completely separate from it. This fits with an integrated and participatory management style in water and coastal management.

A third common strand is one of transdisciplinary knowledge-sharing. As discussed before, multi-party collaboration is nothing new in (Dutch) water management. Coastal management is familiar with including different types of knowledge, as the necessity of knowledge from actors other than decision makers and (civil) engineers is recognized. Nevertheless, the issue of how coastal system knowledge can be shared reciprocally between scientists and stakeholder communities remains challenging.

2.4.2. What is co-design?

We characterize co-design in the coastal context as:

- A 'co-design activity' is a specific, collaborative, design-oriented effort, delineated in time and scope.
- Co-design activities involve designers and non-designers, citizens and/or disciplinary and practice-based experts creatively working together.
- A co-design activity facilitates integration across academic disciplines and public areas.
- Collaboration between participants can occur frequently in all phases of the co-design activity and throughout all phases of the decision making process.
- The scope of the co-design activities in this research fits in a context of coastal management and/or complex coastal systems.
- The specific contextuality of the coastal context prescribes tailor-made co-design activities and methods for finding appropriate solutions.
- The dynamic system complexity and understanding of the dynamic system complexity by various actors are considered key for finding good solutions.
- Underlying rationales for initiation of stakeholder-engaged co-design activities are based in idealistic or pragmatic rationales.
- Co-design activities are transdisciplinary, and can on the one hand involve interdisciplinary collaboration, as coastal management relies heavily on engineering disciplines, policy expertise and other scientific disciplines, and on the other hand collaboration with public participants, or both.
- Research on co-design occurs along two epistemic paths, and uses various knowledge sources, i.e., contextual and scientific knowledge sources.

2.4.3. The theoretical promise of co-design activities within a coastal management context

The theoretical promise of co-design within the coastal context is listed by describing the potential advantages of co-design activities, deriving from the investigated literature.

The theoretical promise embodies a holistic way of conceptualizing reality underpinned by social-ecological systems thinking and transdisciplinarity. A systems approach has proved to be useful in seeking to compare diverse activities, each exhibiting nested-scale problems with complex social (pt. 2) and bio-geophysical (pt. 1) dynamics. Additionally, theoretical promise (pt. 3) addresses the linkages between the social, biophysical and governance aspects that are relevant in a coastal context – specifically addressing a transdisciplinary systems approach (see also Slinger et al., 2020).

As such, this theoretical promise forms a framework which recognizes different types of outcomes and knowledge necessary to resolve complex coastal problems. These outcomes are embedded, meaning that the knowledge sharing is a reaction to enhanced shared understanding of the system complexity (Vreugdenhil, 2010). Together, these provide the potential effects of co-design activities in

Table 2-2 Theoretical promise of collaborative, design-oriented activities (co-design)

1. Enhanced shared understanding of natural system complexity, for instance including the following elements:
    a. Addressing the interrelations between the geophysical and ecological subsystems.
    b. Within the geophysical system, advanced interpretation of geomorphological and hydrodynamic influences.
    c. Analysis of the character of the geophysical system's ability to maintain the diversity and quality of habitats characteristic of the ecological system.
    d. Analysis of environmental impacts on a complex coastal system, within practical spatial bounds.
    e. Improved representation of external influences, such as meteorological impacts and climatological impacts on the coastal system.
2. Enhanced shared understanding of social system complexity, for instance including the following elements:
    a. Representation of local and indigenous knowledge of the coastal system.
    b. Addressing the knowledge and perceptions of involved actors and non-involved local stakeholders
    c. Addressing the differences and interrelations between the social, institutional and governance subsystems.
    d. Early consideration of solutions that lie within the social components of the coastal system, especially relating to multi-actor complexity and institutional complexity
    e. Linking solutions to the policy context, by designing or implementing adaptive, long-term planning within feasible budget ranges and time frames, robust governmental changes.
    f. Addressing the constraints and opportunities offered by institutions (rules, norms, habitual procedures etc.) for potential solutions.
3. Improved knowledge sharing
    a. Sharing of scientific knowledge on the abiotic and biotic aspects of the coastal system, technical/engineering knowledge, and social science knowledge on policy making, institutions, and governance of the coastal system.
    b. Identification of interactions and interfaces between subsystems (social, governance, environmental).
    c. Knowledge exchange between inter- and transdisciplinary participant groups
    d. Using compatible scales by aligning solutions and appropriate time and spatial horizons.

coastal management. These desired outcomes consider system complexity in the bio-geophysical subsystem, in the social subsystem, and considering integration between those subsystems. Summarizing, we distinguish three promising categories: improved knowledge sharing between and across the scientist and actor networks and enhanced shared understanding of the natural and social system complexity (Table 2-2). This theoretical promise can function as a conceptual lens to study projects that use co-design in their context, is intended to serve as an initial guideline to identify desired outcomes, and supports ex-post evaluation of co-design activities in practice.

2.4.4. Relating theoretical promise and design principles

The theoretical promise of a co-design activity relates to its desired outcomes. The underlying conceptual structure in Figure 2-5 leans on a policy analytic perspective. Figure 2-5 depicts a simplified version of a key underlying assumption of these theoretical findings, namely that causality is assumed. Under this assumption, implementation of the design principles affect the design of a co-design activity, influence the application, and as such, would lead to the desired outcomes. However, such an idealized causal mechanism, if existing, is in practice indirect, implied and underlying, owing to the contextual complexity of such social activities. Indeed, the contexts indirectly influences the co-design activity in convoluted ways that are not always explicit. Additionally, nested effects occur, and no single relation can be distilled from design to promised outcomes. With Figure 2-5, we underline the implied underlying causal aspects between the theoretical promise and design principles, but we are careful to not use this as a causal explanatory model.

This structure will be expanded and generalized in Section 3.4. to allow for analysis and evaluation of co-design activities in a structured manner.

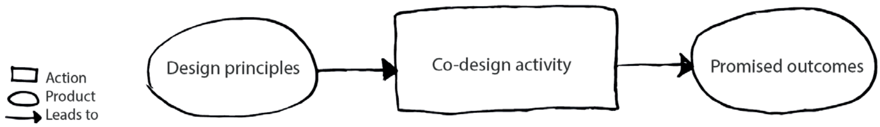


Figure 2-5 An idealization of the assumed causality. The co-design activities are designed with the intent to achieve specific outcomes (which relate to the theoretical promise). The underlying causality implies that implementation of design principles will lead to the desired outcomes.

Table 2-3 Design principles for co-design activities in the coastal context

#	Design principle	Associated design variable
P1	Include local knowledge and local values	Representation of knowledge
P2	Include scientific knowledge	Representation of knowledge
P3	Facilitate knowledge sharing	Representation of knowledge
P4	Give local community and experts equal voices and standing	Representation of knowledge; Trust
P5	Account for contextual specificity and systemic complexity	Problem scope
P6	Appropriate scope	Problem scope
P7	Aim for transparency of relation with policy process	Problem scope
P8	Aim for transparent research	Trust
P9	Appropriate participant selection	Participants
P10	Appropriate moment of citizen involvement	Phase of the design process
P11	Strive for a creative level of engagement practice	Methods
P12	Strive for collaborative learning and building shared system understanding	Collaboration
P13	Avoid mismatch rationale and goals.	Reasons for doing co-design

2.4.5. Design principles for designing co-design activities

The design variables identified in this chapter are in this section presented as 13 design principles (Table 2-3). The design principles follow from the central issues of designing co-design activities and are manifestations of design variables that are elaborated below.

The design principles form an attempt to prescribe how to design co-design activities in the coastal context that fit with the scope of this research. However, the craft in designing co-design activities for the promised outputs lies in connecting the design principles to the relevant context.

The design principles are used to cross-compare the primary case study and secondary activities, so as to draw lessons from the observed collaborative activities in Chapter 6.

Representation of knowledge (P1. Include for local knowledge and local values; P2 Include for scientific knowledge, P3. Facilitate knowledge sharing; P4. Give local community and experts equal voices and standing)

Contextuality of the coast requires tailor-made processes and finding holistic solutions that fit with the context. Knowledge from various sources is required to co-design in the coastal context, and should therefore be included (P1 and P2) and shared (P3). Both bodies of knowledge should be valued equal in the co-design activity (P4), as the types of knowledge used in the co-design activity, and whether they are considered equally valuable, determine the outcome of the solutions. Additionally, references, interests, power, resources and objectives are very common elements of actor analyses. Unfortunately, actor's underlying values are often unconsidered. This is unfortunate, because the value space may be the place where people find common grounds. However, exceptions may exists depending on the purpose of the activity. Indeed, even the most holistic and complete conceptualizations of systems sometimes exclude citizen values.

Participants (P9. Appropriate participant selection)

Participants in co-design activities might include (a selection of) stakeholders, i.e., people that have an interest in the system being analyzed. Participants may include end-users of a project (e.g., recreationalists, home owners, farmers), project management staff (e.g., spatial planners, civil engineers), specialists (ecologists, jurists), or decision-makers (e.g., water board staff, municipal public servants). Whoever contributes to the activity, they bring their perspectives, values and specific sets of knowledge, that is formal, informal, or a combination of both.

Methods (P11. Strive for a creative level of engagement practice)

Specific contextuality of the coastal context prescribes tailor-made processes and finding holistic solutions. There are many methods that involve design, participation or both. Co-designing activities inherently involve some level of creativity, and when designing a co-design activity, one should strive for finding the right level of creative engagement (P11). Methods may be decided upon for pragmatic reasons, and are usually linked to the purpose of the activity. For instance, co-design activities may be used to connect the context and the knowledge base with each other. Additionally, the process of designing collaboratively serves as a communication process between actors of different background, or as an innovative way to attract participants to the activity itself.

With this in mind, commitment to a co-design activity can be difficult for decision-makers or other actors. Especially with design activities in complex systems, where the designed solutions are by definition not known in advance, it makes sense to institute adaptive success criteria and outcomes. Goal posts can be set by organization and initiators, but also from the participants, or from external actors. Predefined criteria may have the advantage that the project and its evaluation, and therefore perceived success, are transparent, but may be disadvantageous as they cannot incorporate learning and adaptations during the co-design. Choices for methods should be made accordingly.

Phase of the design process (P10. Appropriate moment of citizen involvement)

Aside from *whom*, the question of *when* to invite other people to the design table is related to the purpose of the activity its relation to the nested design or decision making process. Co-design conducted for stakeholder empowerment purposes will most likely involve participants earlier in the process, for example by defining requirements of alternatives. For instance, co-design conducted for eliciting local knowledge in the idea generation phase will focus more on extensive discussion and will rely heavily on qualitative documentation to support design phases later in the process.

Level of collaboration (P12. Strive for collaborative learning and building shared system understanding)

Collaboration between different disciplines is often required, as coastal management relies heavily on engineering disciplines, policy expertise and other scientific disciplines. Collaboration between people of different backgrounds and disciplines is challenging. People coming from different perspectives, use different languages (jargon) and analytical frameworks, may prove to be time inefficient. Some organizers deal with this by separating participants based on background, thus limiting the room for discussion and interdisciplinary learning.

Trust (P6. Aim for transparent research; P4. Give local community and experts equal voices and standing)

Co-design activities involve human participants, either in professional or personal capacity. Trust between the participants (interpersonal trust) is beneficial to co-learning and knowledge exchange (Tromp, 2019). Relations between actors are important in a social system, since they shape processes and add to the complexity and complex reality of navigating decision-making practice. Additionally, perceived success of an activity can differ, because values and perceptions differ among actors. Organizers and facilitators can be independent, or closely associated to decision-makers and policy makers. They can be internal or external to a project. They even can act neutral, but still not be not perceived as neutral, which may hinder knowledge exchange.

Other types of trust are trust in the activity and in the organization (procedural trust). A way to facilitate trust is by increasing procedural trust by being transparent about the research process, the limitations of the research and also about research ethics. As such, it is important to be diligent about research and ethics protocols, not in the last because it may influence the actions of the participants. Bad protocols may inhibit trust and information supply. For instance, if participants have a stake in the final designed solutions of the co-design, but are not certain whether they can speak freely or leave the co-design activity, they may not speak their mind. Communication about the purpose of the activity, about the limitations of the activity, about any further (research) steps can be factored in to facilitate trust. Additional questions involve whether data, especially personal data, is stored appropriately, and whether the participants are allowed to leave the activity at any time before the end. Especially in the case of scientific research, published findings are to be anonymized, and should follow the guidelines of a Human Ethics Committee.

Reasons for doing co-design (P13. Avoid mismatch between rationale and goals)

Co-design activities are initiated for idealistic purposes (e.g., democratization), or pragmatic purposes (e.g., to minimize opposition or gain local knowledge). The stated purpose of a co-design activity may be incomplete, or different from the actual rationale for doing so. Also, there may be a difference between the purpose stated by the organizers in the project communication (e.g., learning from stakeholders), and the actual purpose of the organizers (i.e., decreasing opposition). For instance, are the eventual results and use of the activity evaluated based on democratic impact? Success is related to the results, but also to the effects that were not originally planned and in the study (Twaalfhoven, 1999). To address this subjectivity of success in relation to the purpose, which may be perceived differently per actor, and to address the concern that stakeholder participation is not living up to many of the claims that are being made (see also Reed, 2008), we have defined principle P13 in this research. Principle P13 prescribes avoiding a mismatch between rationale and goals, contributing to transparency and potentially allowing for evaluation of the activities against these reasons.

Problem scope (P5. Account for contextual specificity: appreciation of system complexity (actor network complexity, governance complexity and bio-geophysical system complexity); P6. Appropriate scope; P7. Aim for transparency of relation with policy process)

The complexity of coastal systems stems from their social, environmental, institutional and technological subsystems, and the interrelations between these subsystems. Additional complexity stems from the different scales and levels associated with coastal systems and imply the consequences of choosing system boundaries. It is possible to choose time horizon too short to respond to deal with long-term developments, or a jurisdiction not fit to address the issues on a lower level.

Challenges in management of systems with social and ecological components, such as coastal management, are often based in misunderstanding of such scales and their cross-scale dynamics (Cash et al., 2006). Cash distinguishes three common challenges related to scale-issues for management of such systems: ignorance, mismatch, and plurality. First, ignorance is a fundamental challenge. Lack of understanding spatial of and temporal scale issues leads to all sorts of management problems (Folke et al., 1996; Holling, 1973). Management decisions on a national level may lead to local problems, or vice versa: local actions accumulate into larger scale issues. Second, the mismatch between human actions and ecological systems is common (Vreugdenhil et al., 2010). A classic example of a spatial mismatch is trans-boundary pollution: water pollution is both a local and regional problem. A temporal scale mismatch issue is for example when electoral cycles are too short to address coastal management strategies, which by necessity require long-term investments. Third, plurality refers to scale issues that are driven by the urge to frame problems on a single level or scale, as if there is one right scale choice. This drive comes from 'the need to both simplify and control' (Cash et al., 2006). For instance, sea level rising is global, but can also affect regions differently (i.e., the Dutch coast or local agriculture). Additionally, perspectives on scales and levels are perceived differently among actors, which may form a barrier when a diverse group of actors need to communicate, collaborate, or learn from each other (Vreugdenhil et al., 2010).

Therefore, co-design activities in this complex context should account for a holistic understanding of system complexity. Additional complexity owing to the nestedness of the problem situation stem from the temporal and spatial horizons (Figure

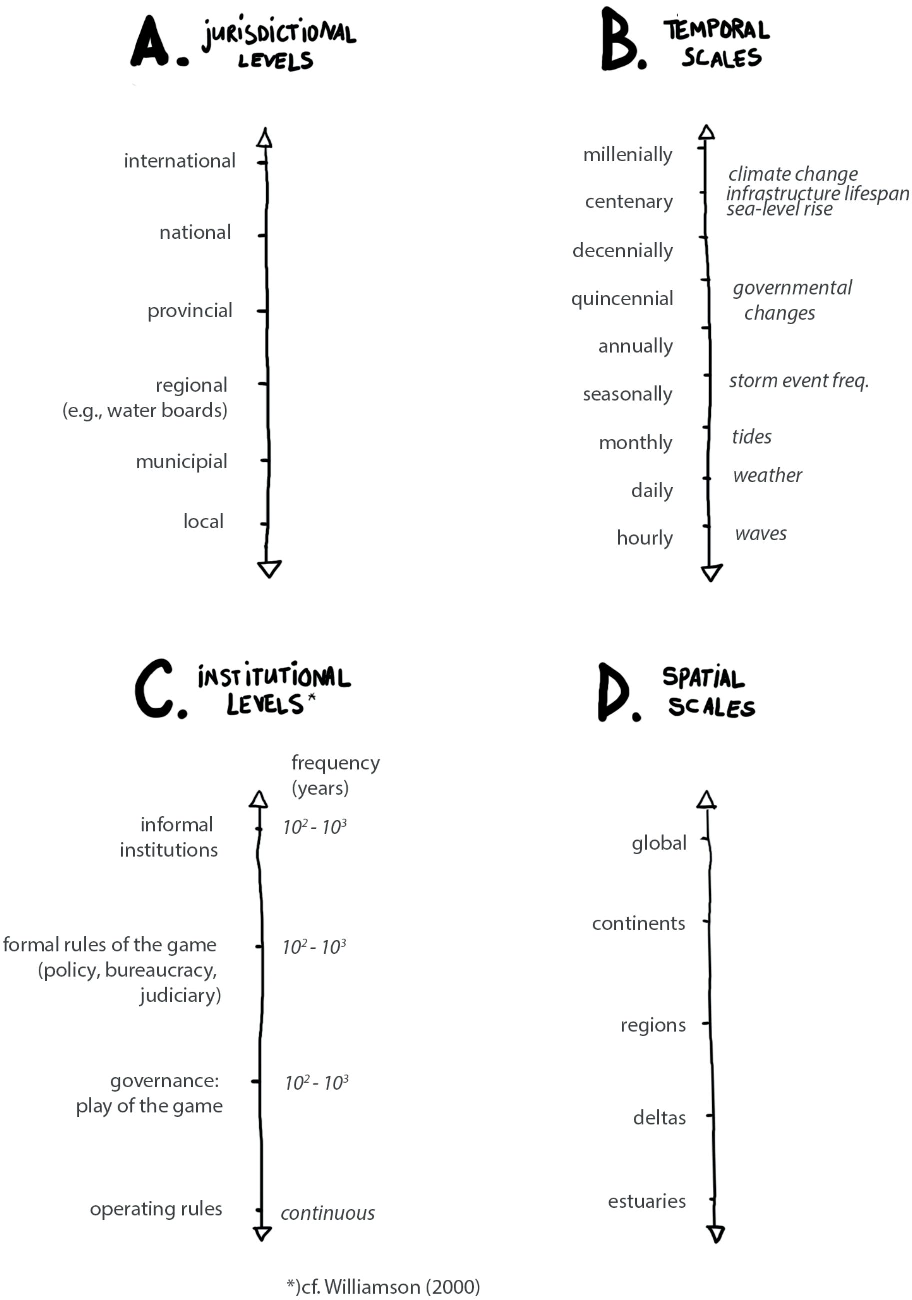


Figure 2-6 Different scales and levels that are used in understanding coastal systems. Adapted from (Cash et al., 2006; Williamson, 2000) to fit the coastal context.

2-6). On which temporal scale do the problem (and the solution) exist (e.g., daily, monthly, seasonally, annually, and decennially) ? On which jurisdictional level does the solution play out (e.g., local, municipal, and regional, national, international)? On which spatial scale does the problem exist (in a habitat, an estuary, a deltaic region, a continent, the globe)?

Issues may arise when choosing a particular scope, including the risk of a lesser degree of stakeholder engagement, for instance because the urgency of problem in the co-design activity is not shared by participants, which can lead to different outcomes (De Bruijn & Heuvelhof, 2002). In another example, problem situations that are urgent, but do not align within the living environment of participants (e.g., participatory activities on the topic of off-shore marine biology processes) can lead to unwanted results.

CHAPTER 3

Research design

In previous sections, we have described the coast as having a governance context, a social context, an ecological context and a technological context. Additionally, we made the choice to study co-design in this complex coastal context.

As this research is interdisciplinary in nature, we first employ our conceptualization of the context to justify the overall research approach and elaborate on a paradigmatic world-view to support the methodological choices and the overarching research approach (3.1). The second section (3.2) presents the research process and briefly introduces the research elements. Elements of the research are described in more detail in the following sections, including the selection of the observed secondary activities (3.3), how the activities will be analyzed and cross-compared (3.4). This chapter concludes with some ethical considerations (3.5).

3.1. Methodological considerations

3.1.1. Interdisciplinary research

The differentiation into science branches on the one hand and the demand for integrated solutions to real-world problems on the other hand necessitates knowledge integration. This underlines the interdisciplinary character of this research. Therefore, we lean on perspectives, ideas, and research approaches that build on integration of knowledge across disciplines.

3.1.2. Philosophical world-view considerations

Following Guba and Lincoln (1994), a research paradigm is defined here as the world-view, or basic belief system, that guides the investigator in ontologically and epistemologically fundamental ways, as well as in choice of method. World-views may also be called knowledge claims (Creswell & Clark, 2007), or broadly conceived research methodologies (Neumann, 2000). Paradigms can be characterized by answering questions regarding their ontology (i.e., 'what is the form of reality and what can we know about it?'), epistemology (i.e., 'how we know what we know?') and methodology (i.e., 'how can the inquirer go about finding out what he or she believes can be known?') (see also Guba & Lincoln, 1994). Here, ontology refers to multiple, sometimes conflicting constructs of reality. Multiple social realities exist in the form of multiple, intangible mental constructions, which are the products of human intellects, apprehensible but sometimes in conflict with each other. Such constructions are not 'true' or 'untrue' in an absolute sense, but they can be more or less informed and/or sophisticated (see also Guba & Lincoln, 1994). Conversely, epistemology refers to the notion that knowledge is value-dependent. Knowledge is perceived to be value-mediated and therefore value-dependent, with knowledge created in interactions among inquirer and respondents (see also Guba & Lincoln, 1994).

This research deals with multi-actor complexity in a nested system, and system knowledge is emphatically viewed as something that can be increased, that can help improving supported design solutions, and that can be shared between scientists, experts and (local) stakeholders. Also, different types of knowledge (model-based, technical design knowledge and local community knowledge) are recognized in this research project (see also Max-Neef, 2005).

So, we adopt a constructivist paradigm. This paradigm assumes that individuals seek understanding of the world in which they live and work. "The appeal of the constructivist paradigm lies in the promise to explain how normative truths are objective and independent of our actual judgments, while also binding and authoritative for us." (Bagnoli, 2017). Additionally, constructivism rejects the idea that knowledge can be completely formalized and classified. As such, researchers aim to look for complexity of views rather than categorizing and narrowing meanings. From this follows that conceptualizations and conceptual models are used in instrumental ways in constructivist research: to communicate, teach, or show perspectives, and not as a complete truth.

3.1.3. The overarching research approach

This research sets out to learn about co-design in the coastal context by analysis of theory to distill the theoretical promise (Chapter 2), by analysis and cross-comparison of the empirical material, and by a reflection (see also Figure 3-1).

In examining the empirical material, we do a qualitative case study in which we choose to learn by designing, organizing, applying, observing and analyzing a number of activities in an overarching co-design process in a primary case study. As such, the primary case study leans on action research, as it is an experiment that aims to solve a 'real-life' problem in the form of an intervention (Burns, 2005, p. 38; Denscombe, 2010). We design a co-design process to fit its specific coastal management context, to account for ongoing learning from the participants during the case study, and to accommodate the unpredictability in the case study. The reflective process and actions are directly linked, and are influenced by participants' and researchers' embeddedness in culture, local contexts and social networks (Baum et al., 2006). Methods that are used in the primary case study need to be able to support both ongoing learning and adaptation, and collaboration between researchers and participants.

We supplement the findings of the primary case study by observing other collaborative activities in the coastal management context: 'the secondary activities'. These we do not term case studies, because they are observations of single activities which do not exhibit all the specified elements of co-design activities. They are not 'cases' of co-design. The purpose of the secondary activities is to extend the findings of the primary case study to the Dutch coastal management practice. The purpose is twofold: 1) we learn on the link between process and outcomes through observation and analysis, and 2) we investigate whether we can extend the validity of the findings of the primary case study to broader classes of observations (see also Jahn et al., 2012; Seijger, 2014; Yin, 1994), within the Dutch coastal management network. The selection of the observed secondary activities is further elaborated in Section 3.3.

The primary case study and the observed secondary activities all investigate phenomena in their contexts. Therefore, we take lessons from case study research for the overarching qualitative research methods. We use a qualitative approach, to explore and understand the meaning that various actors ascribe to the investigated problems (see also Creswell, 2013). The activities we investigate in this research are strongly embedded in, and influenced by, their 'real-world' context (see also Jahn et al., 2012; Sanders & Stappers, 2008). Case study research involves analysis of complex social phenomena within their context, where the distinction and boundaries between context and the phenomena are not always clear (Yin, 1994), and therefore informs the empirical inquiry methods for investigating both the primary case study and the secondary activities in coastal management (see also Yin, 1994). The richness of generated knowledge with a particular case, its dealings with real management situations, and close interactions with stakeholders and practitioners are reasons why case studies are acknowledged to be useful tools in management research (Gibbert et al., 2008; Gibbert & Ruigrok, 2010).

The qualitative research is thus characterized by data collection from multiple sources, and at the site where the activity is experienced (Creswell, 2013). In this research, participants are a key data source, but data is also collected through examining documents, observing behavior and interviews (see also Creswell, 2013). As the procedures for assessing the validity and reliability of case study research are not standardized (Gibbert et al., 2008; Gibbert & Ruigrok, 2010; Pratt, 2008; Yin, 1994), we aim to ensure the rigor in our research in four additional ways. First, we make assumptions about causality explicit (see also Seijger, 2014; Yin, 1994). Second, we aim to gather sufficient empirical data from multiple sources (see also Yin, 1994). Third, we provide a detailed primary case study protocol to support transparency (see also Buthe et al., 2015), for reproducibility of the study (Yin, 1994), and to minimize the risk of (unreported) biases and errors (see also Seijger, 2014). Finally, protocols and other methods are in place for collecting data.

3.2. Research process

This section further describes the research design by providing an overview of the different research elements, and how they are linked to the research objective and research questions.

The general objective of the research is to *understand how to design and strengthen co-design activities in a coastal management context*. Here, we define a 'co-design activity' to indicate a specific, collaborative, design-oriented effort, delineated in time and scope. In this research, these co-design activities focus on coastal management problems.

Table 3-1 The relation between the research elements to the research questions.

Research element	Contributes to research question	Section
Analysis of theory	RQ 1: What is a conceptual understanding of co-design? RQ 2: What does theory say about the promise do co-design activities, and how can this be realized in a coastal management context?	Chapter 2
Research design	n/a	Chapter 3
Primary case study	RQ 3: How do co-design activities contribute to coastal management in practice? How to design a co-design activity in the coastal context (RO)	Chapter 4 & Chapter 5
Secondary collaborative activities	RQ 3: How do co-design activities contribute to coastal management in practice?	Chapter 6
Cross-comparison	RQ 4: How can the contribution of co-design activities to coastal management be strengthened?	Chapter 6
Synthesis	RQ 4: How can the contribution of co-design activities to coastal management be strengthened?	Chapter 7

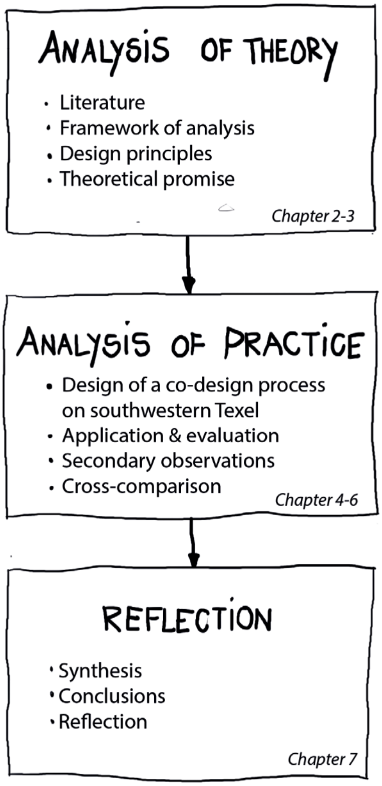


Figure 3-1 Visual outline of the research process and research structure

Each of the research elements presented in Table 3-1 contributes to a research question. We note that the literature study that was presented in Chapter 2, contributes to RQ1, as a conceptual understanding of co-design is obtained. Additionally, the theoretical analysis yielded the theoretical promise of co-design activities for coastal management problems, and serves as a stepping stone in investigating how to design co-design activities (RQ2). The empirical part of this research comprises a primary case study, including a co-design process design. We supplement the findings from the primary case study with of a number of observed collaborative activities in coastal management practice, contributing to answering RQ3. Cross-comparison of all observed collaborative activities and a synthesis serve to answer RQ4.

Figure 3-1 depicts the different research phases. First, the theoretical promise of co-design activities in the coastal context is determined from the literature, and design principles for designing co-design activities are derived.

We then look for key characteristics from practice by analyzing the primary case study and each secondary activity in a qualitative manner. We interpret these by exploring how the outcomes align with the theoretical promise of co-design, attempting to answer the question "why things happened the way they did?".

After the primary case study and each of the observed secondary activities have been studied in this way, we synthesize and cross-compare the observed activities to identify whether and how the design principles were applied, and whether the observed outcomes align with the theoretical promise. Additionally, we attempt to draw lessons about co-design activities on the basis of the quality and degree of implementation of the design principles.

3.3. Case study and collaborative activity settings

3.3.1. Setting of the primary case study on southwestern Texel

The primary case study is the core of the practical part of this research. In this case study, we initiate, design, organize, apply, observe and analyze a co-design process. The selected primary case study (**southwestern Texel**) was a essential part of the larger NWO-funded project titled 'Co-designing Coasts using natural Channel-shoal dynamics' (CoCoChannel).

Existing Dutch coastal policy is aimed at preventing erosion by maintaining the Dutch coast through sediment nourishment. This policy ensures that the erosion hotspot south-west Texel receives a large sediment nourishment budget. The case study southwestern Texel, is part of the CoCoChannel project and was initially envisaged as investigating the feasibility of a new multi-functional concept that involves depositing a more 'concentrated nourishment' in the marine environment, further out from the coast of Texel Island, to counter coastal retreat and to provide social benefits (e.g., recreation and nature) in an integrated, flexible and more cost-effective manner (Wijnberg et al., 2013). This concentrated nourishment was conceived as solving erosion problems over the long-term, while also paying off in terms of short-term benefits. A collaborative design approach is hypothesized to be an effective way to achieve this (Wijnberg et al., 2013). However, recent new insights on the geomorphological dynamics of the ebb-tidal delta suggest that a sandy shoal will in time attach to the south-western side of Texel, making the present strategy of nourishing this “hotspot” unnecessary in the long term. But, the single-issue ‘flood defense’ focus of current coastal management practice is prescribing present nourishment practice (Slinger et al., 2020). The case study highlights the need to pay attention to the role of scientific insights and collaboration in designing alternative coastal management strategies that address multiple objectives effectively over time.

The primary case study is a research study - it constitutes an experiment that allowed for freedom in its design. Collaboration with coastal researchers, experts and managers is expected to find a way to combine recent scientific insights and insights from the local community. While the case study focuses on an ongoing coastal erosion, decisions on how to proceed going forward were yet to be made. Therefore, the co-design process in this case study explores options in the idea-generation phase of coastal management solutions (Figure 1-2), and is not directly linked (but parallel) to existing decision making processes.

The technical description of the final choice for methods is presented later, but we already emphasize a key choice here: to specify the focus area to the beach near Paal 9. The eroding beach near Paal 9 provided a problem topic that resonated with local people, as they experienced the erosion problem in their day-to-day life. A sense of urgency is beneficial to stakeholder engagement, as participants are then less likely to exhibit opportunistic behavior (De Bruijn & Heuvelhof, 2002; Thissen & Walker, 2013). This and other design choices in designing the primary case study are elaborated in Chapter 4, which presents the co-design process design in full

3.3.2. Conditions for secondary collaborative activities

Ideally, we wanted to observe other co-design processes in current coastal management practice, as specified in Section 2.4, to answer RQ3. However, co-design in coastal management practice in the Netherlands seems to be limited. Therefore, we choose to supplement the findings from the experiment in the primary case study by observing *collaborative, design-oriented activities in coastal management practice*, knowing that the conclusions on the efficacy of co-design in the coastal context will be limited. The secondary activities are exploratory in nature and exhibit varying elements of collaboration. Each of the secondary activities are day-long observations and are selected through the existing Dutch coastal management design and decision making network. They form components in ongoing coastal management processes aimed at developing innovative solutions. Where we have stated before that co-design in the coastal context ideally addresses solutions that consider social, natural and institutional complexities, none of the observed secondary activities met all of these criteria.

The secondary activities are real-world examples of collaborative workshops happening in the current coastal management network. For the secondary activities, the focus lies on activities that we can observe and evaluate. Additionally, the collaborative activities had to meet the following similarity requirements.

1. The collaborative activities themselves, and information on the collaborative activities, should be accessible, as the research has practical constraints such as time, place, and resources. The workshops were accessed through the professional network of Dutch coastal management.
2. Focus on problems related to the **coastal context**.
3. Focus on **integration of knowledge** at the interface between science and society; or across scientific disciplines; or both. However, the level of knowledge integration in the collaborative activities was different.

Additionally, the observed secondary collaborative activities could differ on the following attributes:

4. The level of **design.** This could be the key activity, or the activity could minimally include elements of design, or form a component in an ongoing process of developing innovative coastal solutions.
5. The level of collaboration, or the form of public **participation** (e.g., Arnstein, 1969).
6. The degree to which the activity is linked to formal **policy making** processes.

An overview is given in Table 3-2.

3.3.3. Selected secondary collaborative activities

To supplement the findings of the primary case study, we also observed workshops that focused on problems in the coastal context: Negril Bay Jamaica (A), Core group meeting Scheldt Estuary (B), Calculation norm for sediment nourishment on the Dutch coast (C), and the Slufter, Texel (D).

These observed activities have in common that they relate to coastal management problems (Table 2-1). Furthermore, the activities all aimed at collaboration and seeking knowledge sharing between people coming from different backgrounds, in some form or another In some cases, such as the Slufter case (D), participants included both people with 'real-world' knowledge about the area and its value, as well as people with disciplinary knowledge gained in their professional capacity. In other cases, such as the calculation norm for sediment nourishment on the Dutch coast (C), the participants were people with more homogeneous backgrounds: most attendants had specific knowledge about coastal morphology, physical geography and/or were civil engineers. The activities also have in common that they came at opportune moments. Table 3-2 lists the selected collaborative activities, their similarities and differences.

The secondary activities A, B and C are real-world examples of collaborative workshops happening in the current coastal management network accessed through national advisory bodies. This gave informational insights in the current status quo of collaborative activities in coastal management practice. The secondary activities focus on employ different methods in different contexts, but all related to coastal erosion.

Table 3-2 Selected secondary collaborative activities and their characteristics (compared with the primary case study)

	Accessibility (accessed through)	Problem focus within the coastal context	Knowledge integration	Aim of the activity and nested process	Public partici-pation?	Relation to policy making
Primary case study south-western Texel	CoCoChannel	Erosion hotspot on SW Texel (focus on Paal 9)	Scientists Policy experts Local community	Co-design for exploring solutions	Yes	No, explor-ative research study (but policy makers involved)
A. Negril Bay, Jamaica	ENW/ NatureCoast	Coastal erosion at Negril Bay	Coastal engineers	Design for new appli-cation area	no	No.
B. Core group meeting Scheldt Estuary, the Netherlands	Deltares	Monitoring of the Scheldt estuary	Stakeholders Ecosystem experts	Building a long-term vision	Yes	Yes, direct
C. Calculation norm for sediment nourishment on the Dutch coast	Deltares	Monitoring of sediment erosion and nourishments	Coastal engineers	Building shared under-standing	No	Yes, direct
D. The Slufter, Texel, the Netherlands	TU Delft	Coastal erosion & environ-mental monitoring	Scientists Local community	Explore role of participants' system under-standing	Yes	No, explor-ative research study (but policy makers present)

A. Negril Bay Jamaica workshop

The Negril Coast is located at the Western tip of Jamaica. Beach erosion is substantial in this area. Proposed measures to combat the beach erosion include a combination of a beach re-nourishment and a breakwater, but the local coastal community actively opposed this plan, owing to the negative impacts on the sensitive coral ecosystem, the effects on tourism, and the incomplete consultation and Environmental Impact Assessment (EIA) procedures, as well as a general lack of trust in the government. Researchers from the project NatureCoast organized a workshop to re-design measures to combat the beach erosion, with as main question: *Can the Sand Engine Concept work in a tropical coast area where there are coral reefs?* In this case, the collaboration occurred in two small groups of interdisciplinary experts from the Dutch coastal management network, who were tasked with designing coastal management strategies.

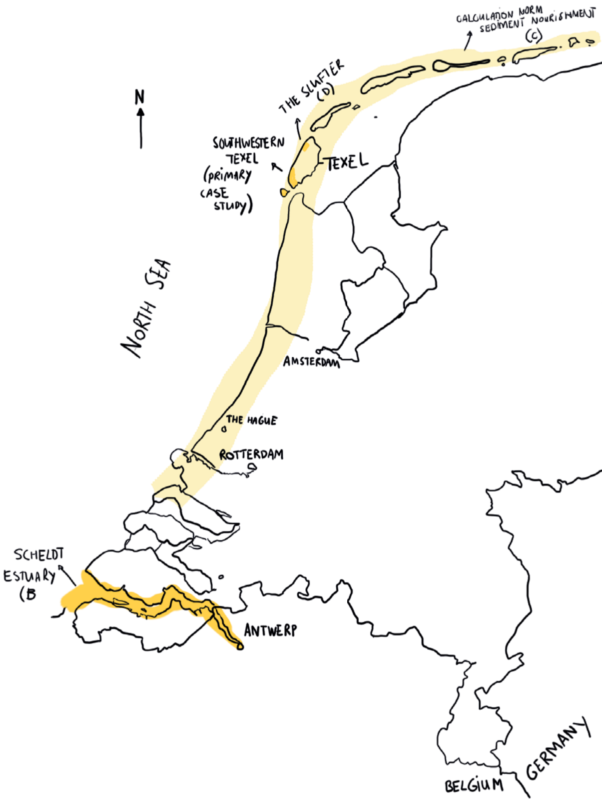


Figure 3-2 Map of the location of the primary case study and the secondary activities. Negril Bay, Jamaica (A) is not on this map.

B. Core group meeting Scheldt Estuary

The Scheldt (Dutch: *Schelde*) estuary lies on the border of the Netherlands and Belgium, and is one of the largest fully tidal estuaries of the North Sea. The Scheldt estuary has a full salinity gradient and sand flats that contribute to richness in habitats and biodiversity. However, environmental changes and human interventions in the area have had negative effects on the Scheldt estuary. The changes in tidal movement, the limited influx from the rivers, and the dumping of dredged sediments may contribute to more muddy waters, which affects the primary production and has other effects in the ecosystem. Human interventions in the system, such as dikes, empoldering, dredging and hard structures, have made the estuary narrower, the channels deeper and the estuary shorter. As such, the high tides have become higher. The area also has economic and social functions, and a wide range of stakeholders are concerned with the area.

To achieve consensus in this actor arena over the factual basis for a new long-term perspective of the Scheldtestuary, the authorities commissioned the Long-Term Perspective Nature Scheldt estuary (LTP-N) in 2016 to investigate the robustness and resilience of the Scheldt estuary, considering climate change and use of the estuary. The observed workshop was part of a longer participatory process related to the long-term vision of the Scheldt estuary. This process, and the observed workshop as part of that process, is a good example of an attempt to create shared system understanding in collaboration with local stakeholders. There is a direct link with policy processes, as the intended outcome of the process is to advise the *Vlaams-Nederlandse Scheldecommissie* on further management strategies related to the estuary. The observed meeting was on 24 October 2018, and a core group of stakeholders participated.

C. Calculation norm for sediment nourishment on the Dutch coast

This workshop 'Kustgenese 2; Invuloefening Rekenregel Suppletievolume' took place on 3 October 2018. The purpose of the day is to explore, extract and synthesize deep tacit knowledge from coastal experts who were involved in the Kustgenese 2 project through discussions in smaller breakout sessions. The workshop serves to explore the assumptions underlying the calculation rule for nourishment volume norms along the Dutch coast, based on preliminary insights on the effects of changes in sediment nourishment policy. This activity is therefore an example of using (preliminary) scientific insights to build a shared understanding among experts. The topics of the breakout sessions related to sediment dynamics in different regions in the Netherlands and the implications for nourishment practices. There were four observers, to observe all of the breakout sessions. The analysis focuses on one of these breakout sessions. In addition to the note-taking, an ex-post survey was conducted to gather specific information on the background of the participants and their opinions on the collaboration and their perceived learning during the day.

D. The Slufter, Texel, the Netherlands

While the existing management practice is to periodically straighten the estuary mouth so as to mitigate the flood risk to the dike landward of the Slufter, new coastal modeling insights led to an incentive for the water board to reevaluate their mouth management strategy of the Slufter. In this collaborative activity, researchers adopted a social-ecological lens is adopted from the outset, which means that the issue of mouth management was expanded to include the ecological and social value of the Slufter area. This activity involved a process of stakeholder engagement in which the perspectives and values of local stakeholders were explored with the aid of system dynamics modeling insights.

The Slufter collaborative activity explored the role of formal knowledge in deepening system understanding, through a stakeholder engagement in a workshop setting before the start of this thesis research in 2014. As researchers, we know the methods, process and results, as we initiated, organized and evaluated the collaborative activity (D'Hont, 2014; D'Hont et al., 2014; Slinger et al., 2020). An additional difference involves the focus on dialogue between local participants and disciplinary experts, as opposed to design.

In 2014, the collaborative activity was part of a scientific research project that investigated the role of system understanding in support of integrated management of the Slufter. The Slufter activity (D) was selected in a different way than the other secondary activities, as it is selected because of its comparability with the case study on southwestern Texel (primary case study), on the basis of geographical proximity and similarities in the actor network. In the current research we analyzed the data in a way that departs from the previous research (D'Hont, 2014; D'Hont et al., 2014; Slinger et al., 2020), as we used the findings to compare on the design principles for co-design activities.

3.3.4. Data collection

We record observations through note-taking. The notes are descriptive and include observations on the participants, a reconstruction of the dialogue, descriptions of the physical setting in which the workshops take place. Notes are reflective enough to draw lessons on the methods, analysis and the quality of workshop products. As a backup, audio recordings are made, after explicit verbal consent from the participants and facilitator(s). The attendance of the observer is also explicitly approved beforehand by facilitators and participants. To ensure similar interpretation, we chose to include only the observed workshops from the same observer for the secondary observed activities if necessary, and audio-recordings were made to confirm the interpretations of procedures, content and process of the co-design activities ex post.

3.4. Cross-comparison

Comparing different collaborative activities requires a conceptual framework to identify key elements. Through analysis, we link findings from practice in the activities to the theoretical promise of co-design (cf. Kallis et al., 2006). The conceptual structure of the framework links theoretical to empirical findings, or more specifically, the theoretical promise of co-design with the characteristics of the activity.

A framework of analysis delivers a structured way to analyze and interpret a wide variety of individual collaborative activities, and facilitates both case-by-case learning and cross-comparison between the primary case study and the secondary activities.

3.4.1. Framework of analysis

For the framework, we lean on theory on evaluation. Evaluation is the reflective act of assessing actions or things. Evaluation in general goes back to the 18th century with e.g., student evaluations (Bossen et al., 2016; Guba & Lincoln, 1989). However, structured evaluation programs were only introduced in the 1960s and 1970s, when certain governments started to ask for assessments of large program investments they had made. In the earlier days, the evaluation field was dominated by positivist and quantitative approaches that presumed the existence of objective knowledge about the efficacy of large governmental programs. Later, the evaluation field expanded to include qualitative and interpretative approaches that questioned the assumptions, ontological and epistemological, of positivism. Currently, the evaluation field comprises realist, interpretivist and constructivist approaches with a wide range of methods, models and theories on evaluation (Bossen et al., 2016; Guba & Lincoln,

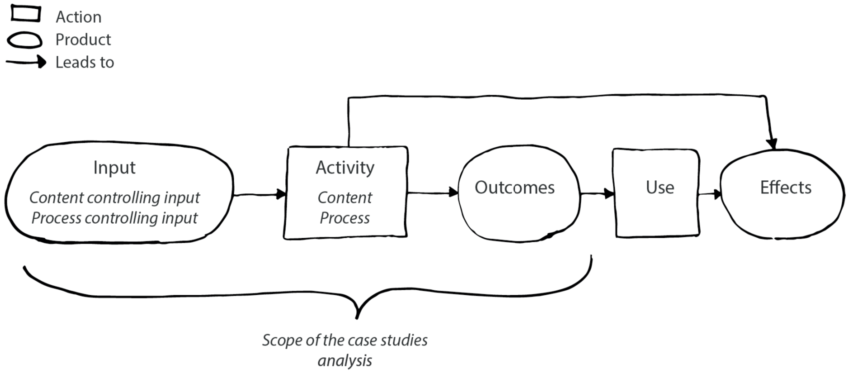


Figure 3-3 Categories of criteria to evaluate co-design activities. Adapted from Thissen and Twaalfhoven (2001). Contextual variables are not explicitly mentioned in this structure.

1989). This means that in social sciences, where the tendency towards a constructivist approach (or interpretative) is prevalent, questions of who is conducting the activity, who is participating, for which goals, and based on which criteria, are important.

Policy analysis, informed by systems thinking, recognizes a wide range of methods in organizing and presenting information to those involved in policy and decision making (Enserink et al., 2010). Indeed, Twaalfhoven (1999), and Thissen and Twaalfhoven (2001), offer a generic conceptual evaluation framework that is applicable to assess a broad range of policy analytic activities, which they define as "specific analytic effort[s] delimited in time and scope and oriented towards a specific policy issue" (p. 628). Figure 3-3 shows how the 'criteria' are categorized according to a conceptual structure that distinguishes between input, process and content, results, use, effects, and communication (Thissen & Twaalfhoven, 2001; van der Pas et al., 2012). Figure 3-3 is a broader and more generalized structure than the similar structure in Figure 2-5, and allows for investigation of the actual outcomes as opposed to the promised outcomes in Figure 2-5.

Similar structures have been used elsewhere (Bossen et al., 2016; Miser & Quade, 1985), as such structures conveniently allow for describing characteristics over a wide range of studies. The specific 'criteria' that can be used to evaluate the elements, depend on the stance of the policy analyst (see also Howlett & Wellstead, 2011; Mayer et al., 2004; McEvoy, 2019). We learn from these frameworks that it is useful to distinguish between process and content of the activity, especially when comparing very different activities. The content of the activity usually includes *what was produced* in the activity, i.e., the topics, substance, and work products. While we do evaluate the content and the context of each collaborative activity, the focus of the cross-comparison in this research lies on the process aspects of the activities: the things relating to the organization of how the activity was set up and performed.

The categories of criteria from Figure 3-3 are used to analyze and describe the secondary activities in a structured way.

3.4.2. Analysis of the collaborative activities: the primary case study and the secondary collaborative activities

The input is described in terms of content controlling variables, which in most cases relate to the specific observed contexts, and the process controlling variables, which is described by answering the following questions:

1. What is the purpose(s) of the activity?
2. Who organizes and facilitates the activity?
3. Who participates in the activity?
4. What method(s) are applied? Or: what activities are undertaken?

Because the content controlling input is highly case-specific, what is relevant to the context differs per collaborative activity. Examples of relevant contexts are site-specific information about the bio-geophysical system, the research project context, and the institutional setting of the problem.

Then, the activity itself is described in terms of process and content. The description focuses on what actually happened in the activity, because often what actually happened differs from the preliminary process design and the method is adapted. Then, the outcomes are described. Where there is information available, use and effects are also described, even though they are outside of the scope, as described in Figure 3-3.

Then, we use the identified theoretical promise for co-design in the coastal context, which was resulted from the literature study in Chapter 2, to identify key differences between the secondary activities.

3.4.3. Cross-comparison of the collaborative activities

Each collaborative activity happened in a different context, and each collaborative activity employed a different method for collaboration and participation. We cross-compare by interpreting whether the design principles were implemented in the design choices of the organizers, and we interpret whether those design principles are limiting or enabling for the efficacy of the co-design activity. The design principles are introduced in Table 2-3. By cross-comparing the initiatives, we draw lessons on how to design such activities within regional coastal management in the Netherlands. In summary, we distill lessons on how the contribution of activities can be strengthened in a coastal management context (RQ4).

3.5. Ethical considerations

An additional, but equally important consideration stems from the fact that the research involves human subjects. Co-design intrinsically involves real people, whether they are in their professional or personal capacity. Because the research is specifically focused on the human side of things in real-world activities, there is specific focus on context, values, power and trust. The research should conform to ethical standards, not only because it is the moral thing to do, but also because it improves the comprehensive quality of the research (Rau et al., 2018).

Prior to executing the research, the Human Ethics Review Committee of Delft University of Technology approved the research that involved participants. Collected data is safeguarded physically and will not be accessible to anyone outside the study. Human subjects made their consent explicit (see also Appendix G), and the purpose and the limitations of the study should be clear to them. Furthermore, the data was anonymized where possible and is to be destroyed after a scientifically appropriate period of time (see also Research Ethics Checklist for Human Research, version 9).

In this research, the data that comes from human subjects is anonymized as necessary.

CHAPTER 4

Design of a co-design process

4.1. Introduction

This chapter reports on the design of the co-design process (i.e., a series of activities) for the primary case study of southwestern Texel. Indeed, as specified in Figure 3-4, design of a co-design process is in fact a meta-design. While design is a process of iteration, we use these stages linearly to justify our meta-design choices (Figure 4-1) (e.g., Dym & Little, 2004; Taljaard et al., 2013). As this chapter is concerned with justification for the design choices up to the preliminary design, in this chapter we analyze the problem by reviewing the initial assignment, clarifying the objectives, identifying the constraints, investigating the problem context and revising the initial problem statement. The last two stages of the cycle (Figure 4-1), the implementation, and evaluation are presented in Chapter 5.

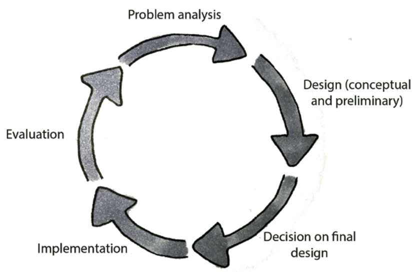


Figure 4-1 Cyclical design

4.2. Problem analysis

4.2.1. Initial problem and requirements

The initial problem statement originates from the overarching research project Co-Designing Coasts Using Natural Channel-Shoal Dynamics (CoCoChannel) (Wijnberg et al., 2013). The emphasis within the overarching project is on the nested nature of the dune-beach system within the long-term, larger spatial scale dynamics of the ebb tidal delta of the Texel Inlet. The proposal clarifies that the nested scale complexity is also reflected in the multi-actor system of south-western Texel, where local, community level decision making is often influenced and constrained by regional and national decision-making. Within this nested actor complexity, the subproject C: Co-designing Nature-based Interventions in Coastal Systems (850.13.043) sets out to explore the role of system understanding in co-designing nature-based interventions in a coastal case study through:

1. A real-life design-in-action approach to the case study of South-Western Texel, so as to integrate knowledge with the other sub-projects which are oriented to this specific case study area (A and B), as well as to enable comparison with case studies with similar bio-geophysical attributes.
2. An application that is fully participatory (i.e., with stakeholders drawn from the public).
3. An application that includes the bio-geophysical system inputs from actors within the design team in designing good nature-based interventions in coastal systems.

As such, eventual designs that are formed through the collaborative design process are viewed as a product of the (dynamics of the) network of scientists, engineers and other stakeholders.
A full specification of the set of goals can be found in the grant proposal (Wijnberg et al., 2013).

4.2.2. Problem context

The contextuality for the southwestern Texel case study, and the execution of this research within the broader research project CoCoChannel, determines and constraints further choices. Here, we briefly describe the issues that have influenced particular choices regarding the co-design process.

Requirements specific to the content controlling input

This research project forms the governance component of a larger NWO-funded project titled '*Co-designing Coasts using natural Channel-shoal dynamics*', or in short: CoCoChannel. The CoCoChannel project is one of five research projects funded by the Dutch Research Council (NWO) within the research program Building with Nature. Innovative research and engineering projects in the Netherlands seek to explore the feasibility of proactive solutions that fight the consequences rather than the causes of natural coastal erosion (Wijnberg et al., 2013). As such, Building with Nature aims for ecological-technical solutions by using natural processes and structures in an innovative manner and with a multidisciplinary focus (NWO, 2014). While Building with Nature is mainly an engineering and research practice, that can use participation and stakeholder engagement, there are few formalized guidelines on how to go about including stakeholder knowledge and system understanding in Building with Nature projects. At present, the option to stop (temporarily) the nourishments on the western tip of the island of Texel has been posited by scientists (Wijnberg et al., 2013) since maintaining the dunes for flood defense is not necessarily required given the wide dune field in this area. Preventing coastal erosion by dynamically maintaining the position of the coastline at the 1990 position is the main objective of the Coastal Defense Act (Hermans et al., 2013). However, other functions of the area may be at stake (nature, recreation, and protection of a bay that serves as a military training area) (Wijnberg et al., 2013). Furthermore, solutions under the umbrella of Building with Nature also require understanding of the social system, and acceptance of varying stakeholder perspectives involved in the coastal problem (De Vriend & Van Koningsveld, 2012; Wijnberg et al., 2015).

Independence from, and interdependencies with, the other CoCoChannel sub-projects. As mentioned before, the CoCoChannel project explicitly aims to undertake transdisciplinary research, seeking to integrate the knowledge of local people as experts in the co-design process. Additionally, there is room for integration

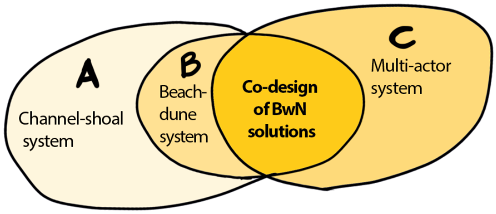


Figure 4-2 Graphical representation of the setup of the CoCoChannel research program (Wijnberg et al., 2013).

with knowledge acquired through sub-projects A and B (Figure 4-2), as they supply content into the co-design process. However, the co-design process should not be dependent upon timely delivery of the results from the other sub-projects for success.

Time constraints. The duration of the research project is limited to a maximum of 5 years. There is therefore little room for a longitudinal study of an actual policy making process, which might take substantially longer

Requirements specific to the process controlling input

The local community. Co-design in this case study involves people in both their professional and personal capacity. Because the governance research is focused specifically on the social aspects of real-world cases, it is important to consider that other decision-making processes, stakeholder engagement work and participatory projects are happening on the island of Texel. The district water board 'Hoogheemraadschap Hollands Noorderkwartier' (HHNK), partner in CoCoChannel, initially expressed concern at the outset that executing the co-design processes may stir up contention on the island. This concern imposed requirements related to the alignment with existing policy processes on the design of the co-design process.

Participants. The island community of Texel is a close-knit community and citizens know how to access and alert relevant authorities (D'Hont, 2014). Local citizens are well-organized and are vocal in stakeholder groups, such as village committees or the organizations that represent 'National Park Duinen van Texel'. Additionally, local and regional authorities frequently organize participatory processes (e.g., HHNK's Texel Workshops) and multiple scientific research projects have been

4

running and currently run on the island, possibly resulting in stakeholder fatigue. The local community are committed to decision-making on their island. However, because of the connectedness of the actor networks on the island, it is difficult to define distinct groups of stakeholders. An additional consideration in selecting and involving participants concerns a small number of assertive people who are reputed to participate actively and vociferously in workshops, in an attempt to raise their interests higher on the agenda. For the co-design process it is important that the interests of less vociferous or assertive people are also heard.

Contextual dependency. The co-design process should be applicable to the southwestern Texel case study, and possibly adaptable to other case study sites.

4.2.3. Case study context South-west Texel

The historical, cultural and social identity of Texel citizens is closely related to the islands' connection with the sea. The inherent dynamic nature of the Wadden Sea area contrasts with the static institutionalization of the North Sea coastline within Dutch rules and regulations. Currently, sediment nourishments are regularly deposited on the shore-face of South-West Texel to maintain beach width and the coast line. However, the level of protection against flooding that is provided by the dunes is already sufficient in this area (Wijnberg et al., 2015). Hence, there is an opportunity to change the current policy of regular nourishment of this part of the Texel coast, because such nourishments could potentially be postponed in order to implement an alternative strategy. An alternative strategy could involve a more Building-with-Nature type solution involving manipulation of the inlet channel, or simply waiting for the ebb-tidal delta to attach to the island.

Bio-geophysical context. The island of Texel is a nature-rich area, and the southwestern point of the island is unique. The nested social and ecological dynamics exhibit different scales adding to the complexity of conceptualizing such a coastal system (Wijnberg et al., 2015). This has consequences for choosing system boundaries in a problem analysis. It is possible to choose a time horizon too short to consider long-term developments, or a jurisdiction not fit to address the issues on a lower level. Additionally, perspectives on scales and levels differ amongst actors, which may form a barrier to communication, when a diverse group of actors need to collaborate, or learn from each other.

Institutional complexity. The frequent sediment nourishment on the Texel coast fit with nation-wide coastal management strategies. Modern coastline management policy in the Netherlands was initiated in the early 1980s (Hermans et al., 2013), when the Dutch Government instituted a national coastal policy of 'Dynamic Preservation' (Eerste Kustnota, 1990). The three-step strategy for coastal erosion management focused on maximizing natural dynamics through: 1) preservation of sand and free transport of sand alongshore and cross-shore of the coast; 2) sandy measures where possible, if management or infrastructural intervention are required; and 3) immobilization of sands by hard structures, only in extreme cases (Mulder et al., 2011). However, the existing coastal management institutions are constantly challenged by pressing issues like climate change, societal usage of the coast and increasing knowledge about the coastal system (Mulder et al., 2011). According to a national policy evaluation carried out in 2007 (Lubbers et al., 2007) , there is a need to improve and develop spatial integration and coherence between different parts of the Dutch coast. This need is exacerbated by the future increase in nourishment demand. Another important evaluative conclusion is that functional integration in Dutch coastal management is only partially achieved (Lubbers et al., 2007). The need to maintain the coastline using sand nourishments for coastal functions goes beyond only coastal safety (Mulder et al., 2011). However, nourishment claims for other user functions (e.g., recreation in coastal towns) require relatively expensive beach nourishments, whereas safety issues can be served more effectively by cheaper shore-face nourishments.

Finances and responsibilities for coastal functions are similarly fragmented over different governmental authorities, where they ought to be involved together (Lubbers et al., 2007). Dutch public administration suffers under fragmentation, where each ministry is focusing on different sub-aspects of societal (and ecological) issues (Geest et al., 2008; Mulder et al., 2011).

Actor complexity. However, other functions of the area may be at stake (nature, recreation, and protection of a bay that serves as a military training area). There is a variety of stakeholders with an interest in changing coastal policies. Generally, any changes that affect or are perceived to affect coastal integrity in Holland are sensitive and subject to scrutiny by local inhabitants and policy makers.

The Texel multi-actor system is one where local, community level decision making often is constrained by the larger provincial and national system. Considering the main issues mentioned above, the main actors include authorities responsible for different aspects and functions of Southwest Texel. The state (i.e., Rijkswaterstaat) is responsible for coastline management, the Water Board (HHNK) is in charge of coastal safety against flooding, the State Forest Authority ('Staatsbosbeer') is responsible for the protection of natural values, and the municipality of Texel is responsible for maintenance of infrastructure and economic development. Besides these authorities, owners and visitors of local beach restaurants and beach houses, beach tourists as well as nature recreationists and inhabitants of the island, represent important stakeholders. A specific stakeholder is the Ministry of Defense, exploiting a training center and small harbor at the north east fringe of the sandy shoal De Hors. Additionally, fishermen and the navy harbor of 'Den Helder' frequently uses the channel 'Molengat' for navigation purposes.

4.2.4. Revised problem statement

Drawing on the understanding of co-design developed in Chapter 3, and the clarification of the constraints in Section 4.2.1, the initial problem statement is revised to the following problem statement. Later design choices follow from this problem statement.

We want a co-design process for the island of Texel, which explores the role of system understanding in co-designing nature-based interventions in a coastal case study. The designed co-design process will be:

A. A participatory activity that engages stakeholders from the public, and also scientists, engineers and other experts
B. An activity that employs collaborative design with the participants
C. An activity that integrates different types of knowledge, including knowledge of the bio-geophysical system, of the governance system, the policy making context, as well as local knowledge about the system under study, namely the island of Texel.

We make two additional and equally important choices for the purpose of this research.

D. The activity is an experiment that is decoupled from, but parallel to, an actual decision-making context.
E. The activity adheres to the design principles formulated in Chapter 3.

The decoupling from other decision-making processes allows for more freedom in configuring the activities. An additional advantage from the decoupling stems from its avoidance of whether local stakeholders trust the local and regional governmental authorities, and consequently, the participatory process. Mistrust for authorities can lead to lack of support for an initiative by local stakeholders in participatory processes (as discussed in Chapter 3). However, decoupling may have the disadvantage that the urgency to engage is felt less strongly by participants, risking a lesser degree of stakeholder engagement (De Bruijn & Heuvelhof, 2002). This is why we choose a topic that is real, and on which decision making process is occurring parallel to the co-design process.

Final design choices follow from the implementation of the design principles in a particular way (see also (Table 2-3). For instance, the transdisciplinary nature of the activity leads to requirements on local and situated knowledge and develop (local, policy, scientific and engineering) experts' system understanding.

4.3. Preliminary design of co-design method

4.3.1. Overall co-design method

We propose a three-step co-design process that comprises three collaborative activities.

Participants will include researchers, policy makers and local stakeholders. We choose to explore what happens when we facilitate local citizens and group of interdisciplinary professionals collaboratively design for south-western Texel. Figure 4-3 shows the overall co-design process in three rounds (blue ellipses). The first round uses a problem and game structuring approach, to include disciplinary and local knowledge, as well as stakeholder values (cf. Cunningham et al., 2014; Kothuis et al., 2014; Slinger et al., 2014). The second round focuses on disciplinary, e.g. geomorphologists, engineers, governance specialists, and accounts for the various roles they can take in designing integrated coastal management solutions. The third round provides a validity check and allows the stakeholder participants to assess and give feedback on whether their values were appropriately included in the resulting

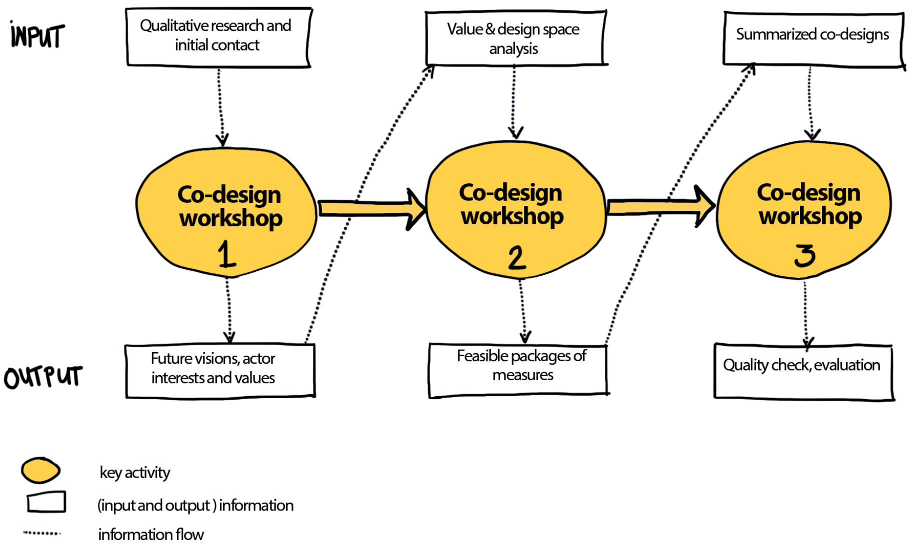


Figure 4-3 Overall co-design approach in three rounds of workshops.

designs. Products and information serving as input and output are visualized with the dark blue blocks in Figure 4-3. Outcomes per round are described in more detail in Table 4-4.

Design choices were made based on earlier lessons on design principles. For example, the choice for separate rounds with different participants in each round is based on design principle P4 (give local community and experts equal voices and standing). This choice is also supported by the observation that disciplinary experts tended to dominate the discussion in the Slufter case study (D). In case study D, participants' opinions and knowledge can be underrepresented and less heard in unbalanced group discussions. Choosing to have different rounds where each type of participant has a place, and alternating the focus on formal and informal knowledge between rounds is intended to mitigate this effect. Another reason for the sequential rounds, is that design processes are iterative in nature. Taking a design and improving it step by step is a key strategy in design science and engineering design. The separate rounds facilitate this process. The different types of participants make this process transdisciplinary.

Table 4-1 Summary of expected outcomes per co-design session

Activities	Expected outcomes
Preparation	
• Preliminary research • Attend and reflect on other coastal management workshops with a collaborative and design focus • Identify and invite relevant actors	• List of stakeholders (i.e., local experts) to invite for the first co-design workshop. • List of relevant disciplinary experts
Co-design workshop 1	
6-step collaborative design session with local experts to design and disciplinary experts to share knowledge scheduled for a full day (cf. Cunningham et al., 2014; Kothuis et al., 2014; Slinger et al., 2014), including: • A group session to create a shared system understanding, by identifying key stakeholder groups ('who cares?') and key system factors and values ('why we care?'). • Local experts work in small groups to develop future (utopic, dystopic and realistic) visions for Texel • Knowledge-sharing from disciplinary experts through (brief) presentations and consultation throughout the day • Local experts rank the visions to determine what is desired and undesired.	• Future visions as designed by local experts • Identified key stakeholder groups • A matrix with the rating of the visions by each of the stakeholder groups. zzzzzz
Intermediate analysis of participants' values	
• Evaluation of designed future visions in co-design round 1 • Mapping design space using Pareto optimum front analysis	• Determine Pareto front by identification of win-win, win-lose and lose-lose outcomes on behalf of all the stakeholder groups. • A coalition check by identification of stakeholder groups that consistently (don't) have aligned interests • Issue elicitation through identification of the visions which – given the situation today – offer the most value for the most stakeholder groups • Value elicitation and determination of design space through interpretation of value dimensions based on insights above

Table 4-1 (continued) Summary of expected outcomes per co-design session

Activities	Expected outcomes
Co-design workshop 2	
Collaborative design session with disciplinary experts (including engineers, geomorphologists, ecologists, coastal managers and governance specialists) to add scientific and engineering knowledge to the designs of round 1; to check for quality and feasibility, scheduled for a day, including: • Update on the status quo: recap of what has been done in round 1 and results of the intermediate analysis • Co-design assignment in subgroups to design patchworks of interventions (i.e., coastal management strategies) to achieve the visions generated by local Texel stakeholders, considering the human-environment system • Evaluate co-designs and co-design process by participants	• Coastal management strategies: patchworks of interventions in the marine and terrestrial environments, and the social and institutional environments. • Peer evaluations among the subgroups • Identification of leverage points to intervene in the human-environment system • Identification of institutional hurdles and scientific knowledge gaps for achieving designed coastal management strategies
Co-design workshop 3	
Feedback session and validity check, for which all participants of previous co-design rounds are invited, scheduled for one afternoon, including: • Feedback results since co-design round 1. Research team with local experts regarding policy strategies to increase system and decision-making understanding • Evaluate entire co-design process from the perspective of the participants • Session ends with a plenary discussion and subsequent dinner as a thank you	• Participants' perceptions regarding co-design process and co-design process results
Evaluation and dissemination of results	
• Process notes and other recording materials • Prepare reports	• Evaluation of questionnaire results • Distribution of workshop report • Results are used to determine lessons learned and specify evaluation framework

4.3.2. Participant selection

The social network and interdependencies, and some understanding of stakeholders' system understanding, stance and values relevant to the problem are needed at the outset. We choose to select different participants for the three co-design workshops. We make the distinction between people having direct ties with the area of southwestern Texel, which we choose to call 'local experts' in this case study. This choice in communication underlines the importance of their contributions and stresses the value placed on local knowledge as well as disciplinary knowledge. Participant selection considerations included selecting unusual suspects, pre-workshop phone interviews and getting a diverse group of participants using actor network analysis. Disciplinary experts are accessed through the professional coastal management network.

Co-design workshop 1

The participants for the first workshop were selected based on desk research, and included findings from earlier research outcomes (e.g., D'Hont et al., 2014). We aim for a varied group, avoiding local experts already involved in other participatory policy processes (cf. Slinger et al., 2007), as the Texel community is well-organized and has access to the policy network (D'Hont, 2014). Participants are selected through a series of brief phone interviews according to the 'snow ball' method, looking for a variety of people in e.g., age, gender, background, education level, occupation. We aim to find people with primary contact and direct interests in the area around Paal 9, with a diversity of people from the nearby towns and villages on the island.

Co-design workshop 2

Participants are experts on disciplines related to: engineering, geomorphology, ecology, coastal management, and governance. Participants are to be challenged on the technological/infrastructural, environmental, institutional and societal context of their work. Their knowledge includes current legal, planning, and technical standards. Participants are selected through professional networks of collaborating research partners, and based on expertise, ability and willingness.

Co-design workshop 3

All participants who attended any of the earlier workshops are invited for the last workshop.

4.3.3. Co-design workshop 1

The first round of co-design workshop is called: 'Co-designing the future of Texel-Zuid; adaptive coastal management on a changing island' and occurred on 2 December 2016. For the workshop design choices, we follow established methods, (cf. Cunningham et al., 2014; Kothuis et al., 2014; Slinger et al., 2014). The approach adopts a planning perspective, and includes problem structuring and gaming elements. It seeks to envision multiple utopian and dystopian future.

Activities and elements. The workshop comprises five steps with the support of a facilitator:

Step 1: Getting acquainted.
A map-based exercise in which participants introduce themselves.

Step 2: 'Who cares?'
Local experts identify and organize key stakeholders in a group effort. -- The participating local experts are asked to identify stakeholders and stakeholder groups that have an interest in, interaction with, or something to do with Texel-(South). Subsequently, the stakeholders are clustered and named, forming key stakeholder groups.

Step 3: 'Why do we care?'
In a plenary session, local experts are asked to discuss what they care about, what they find important and/or worth caring about when considering Texel. Aside from the facilitator, an assistant writes down systematically what is said, thus creating a characterization of Texel and what people value about the island, and more specifically, the southwestern part of the island.

Step 4: Expert presentations on different subsystems and how these systems function.
Three disciplinary experts give a 20-minute presentation on different aspects of the coastal system.

Step 5: 'What do we (not) want?' Collaboratively designing utopian and dystopian futures. The participating local experts designed eleven future visions for the island of Texel in a collaborative setting, using their own knowledge and values, as well as input from the disciplinary experts and policy actors on feasibility of solutions and institutional constraints. The visions are designed in five groups, on paper, with words, maps, drawings and were presented to the group.

Step 6: 'What is important?'
Local experts rank the visions in their assigned role of key stakeholders (of step 1) to determine what is (un)desired. Each key stakeholder group was represented by two participants and received 6 positive and 3 negative votes in the form of stickers to be put on the designed visions affixed to the walls.

Steps 1, 2, 3 and 4 aim to create a shared system understanding and facilitate knowledge exchange. Local experts were asked to design future visions for Texel in small groups, that were utopic, dystopic and realistic in nature, while other participants were asked to supply information where needed (**step 4**). The choice to step to the future is deliberate. It avoids the group becoming stuck in heated discussion of current interventions and is a means of distancing the co-design workshop from current policy processes, while still maintaining relevance for coastal management. In **step 6**, local experts vote on each other's designs while adopting a role of key stakeholder group as identified in **step 2**. We compare the votes in a table. Knowledge-sharing from disciplinary experts happened through (brief) presentations and consultation throughout the day.

4.3.4. Intermediate step: analysis of values

The analysis uses the future visions and their ratings to assess the extent to which the values of the interest groups are represented in the outcomes (see Cunningham et al., 2014; Kothuis et al., 2014; Slinger et al., 2014). Calculations are made to locate the Pareto optimum front. If one single vision were unanimously favored by everyone, it would represent the ultimate solution. However, the multi-actor complexity of the coast means that there is no single, beneficial solution. Instead, with the information about which futures were perceived as favorable or unfavorable based on voting preference, we assess whether alternatives exist that benefit certain stakeholder groups, without hurting others. This forms the design space for the coastal management problem.

The R script used to calculate the Pareto optimality is given in Appendix B. We briefly describe the algorithm here.

First, the complexity of the analysis is reduced, by eliminating the alternatives (i.e., future visions) in which any stakeholder group is made substantially worse off, so lose-lose outcomes and, possibly, substantially lose-win outcomes are scrapped. An alternative is also eliminated if the analysis shows that a perspective is dominated by another perspective, which means that it isn't on the Pareto optimum front. Also, we calculate the percentage of total variance in the voting behavior explained by principal components. The principal components here relate to the underlying stakeholder values that we assume determine voting behavior, so we will call them 'value dimensions' in this context. The value dimensions that are considered to be the most important, as they cumulatively explain the majority (>65%) of the voting behavior are retained, and the others are eliminated to make the analysis more comprehensible.

Then, we try to reduce the complexity of the analysis again, this time by assessing the visions in light of the distinguished value dimensions. We examine the alignment of values. By plotting the visions against the distinguished value dimensions, we can differentiate between favored, unfavored and more neutrally favored future visions.

Often a broad space of agreement exists among interest groups about which alternatives are most desirable. Broad interest coalitions are stakeholder groups that want similar things. We specify these coalitions and juxtapose them by opposing coalitions, thus mapping the actor interest network based on the stated preferences through the ratings of the alternatives. Accordingly, we try to find expressions of the value dimensions that are desirable and undesirable according to these stakeholder groups.

This intermediate step is intended to analyze the underlying values and value dilemmas to participants in the next co-design workshops.

4.3.5. Co-design workshop 2

In the second round, we build on outcomes from co-design workshop 1. Experts from a variety of disciplines relating to coastal engineering, coastal management research and -practice are asked to design coastal management strategies for the case study site in groups of four or five people. These coastal management strategies represent a coherent set of interventions to achieve visions that were generated by local stakeholders in the previous co-design workshop, taking into account the underlying values that shape discussions on coastal management on the island. Secondary objectives include: establishing the feasibility of the solutions offered in the first round, and promoting 'integrated systems engineering'.

Participants are instructed to not only design physical solutions, but to include ecological and governmental elements in their designs. The starting point of the workshop includes knowledge input on local stakeholder values, their utopic and dystopic visions (nightmares and dreams) for their island, and local preferences.

Activities and elements during co-design round 2

Chronologically, the activities undertaken during the day are:

Step 1. Getting acquainted: experts introduce themselves.

Step 2. Results and analysis of the results from the co-design workshop round and the intermediate analysis

Step 3. Introducing the co-design task. The design assignment focused on designing patchworks of interventions to achieve the visions generated by local Texel stakeholders in the earlier workshop. Participants are asked to design coastal management strategies, potentially using the natural channel-shoal dynamics of south Texel, to achieve the visions of local stakeholders (from the first round) taking the revealed underlying value dimensions (from the intermediate analysis) into account. As they are working in a team of five people with different expertise, the participants are asked to think out of the box first, and later consider what would need to change to make their designs feasible (e.g., management practices, rules, processes).

Step 4. Knowledge exchange: newspaper headings. Before lunch starts, the expert teams were asked to write down two headlines: one for the cover of an academic journal such as 'Nature' or 'Science', and one for a 'Breaking News' headline, either for a newspaper or for a news show. The headlines were stuck up on the wall, to be read by participants during lunch. This 'knowledge exchange'-exercise had a dual purpose. On the one hand, it served as a knowledge exchange between the expert groups. They had been working separately for a while, and the headlines showed them what the others were doing. On the other hand, it served as a converging activity for the design groups, to get them out of the brainstorm phase of the design and into making decisions. Also, it provided a light and fun element.

Step 5. Presentation of final co-designs of each expert team. Designs are depicted on a flip-over: including diagrams and/or descriptions of the strategy, why and how it works over time, and relevant calculations. Participants also generate a bullet point description relating to engineering, ecology and governance aspects of their design.

Step 6. Peer review of design and participants' reflections on the day. In a plenary session, the participants are asked to discuss (each other's' and their own) co-designs, as well as the workshop day as a whole.

Co-design groups

One of the aims is to improve the experts' awareness of coastal systems as a complex whole and to introduce them to collaborative design activities. Participants are exposed to design uncertainty issues and a messy problem situation, with no 'right' solutions. We follow the advice from Grant et al. (2010) regarding the configuration of the design setting:

- The design assignment - each discipline feel they can make a significant contribution from their discipline.
- The participant groups - the groups are of equal size and participants from each discipline are evenly represented.

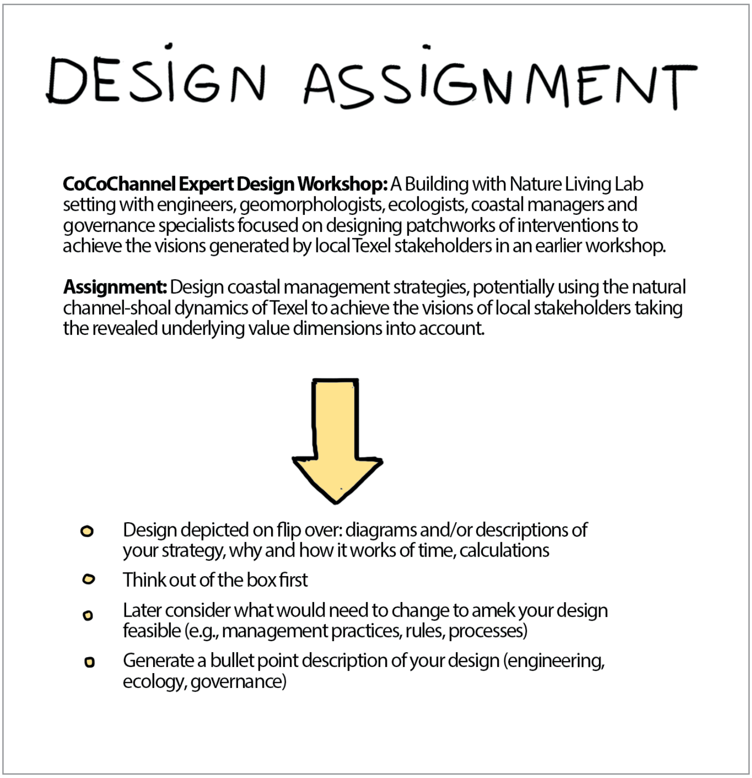


Figure 4-4 The co-design assignment of co-design workshop 2

- The support - staff members can provide support, and participants are encouraged to (and did) ask participants from other groups, to support each other.

Design assignment
The assignment for the co-design assignment is to develop a holistic coastal management strategy (Figure 4-4). For the design assignment, participants are encouraged to think about technological and ecological aspects first and only later look at the current laws and regulations and whether they need to be changed. The information from previous workshops and from the presentation on stakeholder values serve as input. Participants are encouraged to ask each other questions.

Support and facilitation
Three organizational roles need to be filled for the workshop to run well. The roles include facilitation, observation, and time-keeping. Someone with expertise on interdisciplinary collaboration is preferred as facilitator. Additionally, disciplinary specialists providing information on the institutions of flood defense on the island, and information on the morphodynamics of Texel similar to that given in co-design workshop 1 are required. This is to control the input content. For instance, a similar presentation on morphodynamics as was given in round 1. Also, information deriving from round 1 on local values needs to be explained.

Packages of measures
The co-designed artefacts will be the feasible packages of measures, as described in the design assignment (Figure 4-4).

4.3.6. Co-design workshop 3

Support and facilitation
For the final feedback session, all people who participated in the first and second round were invited. The workshop serves as a means to validate the designs from co-design workshop 2. Additionally, the entire co-design process and all its activities are evaluated from the perspective of the participants. Finally, the research could share their insights with participants regarding improved coastal management and policy strategies to increase system and decision-making understanding.

Activities and elements during co-design workshop 3
Participants were asked key evaluation questions based on observations from the research team, plenary feedback sessions at the end of each workshop day; and evaluation questionnaires that were answered by the participants of the third round of the co-design process. The questionnaire addressed the evaluation of work products from the first two workshops (see Appendix F).

Participants' memories are refreshed and they were informed on subsequent design steps through a 20 minute presentation reviewing workshop 1 and 2. In addition to the results from the first workshops, participants are informed about the underlying values and the on the value dilemmas of the intermediate analysis step. The characteristics of the patchworks of measures designed by the disciplinary experts in workshop 2 are discussed as well. The main activities undertaken during the afternoon are:

1. Feedback of information on the results of round 1 and 2
2. Validation feedback of participants to organizers through a discussion and a survey (see below)
3. Conversation about insights from the co-design of the team
4. Dialogue about the future of Texel South
5. Feedback of participants to organizers through a questionnaire.

Surveys

In addition to the group discussions in plenary, we choose to record the opinions and perspectives of the participants in the form of a survey, so as to have tangible and measurable qualitative data. There are limitations to asking questions in this form, so we set the questions to evaluate the designed solutions. The workshop day is designed to include two moments where we would ask participants individually to answer certain questions. The first moment happens after the presentation and discussions of the results of the expert workshop (round 2). Participants are asked two questions to validate the designs:

Question 1: In the presentation you were informed about the intermediate analysis, looking for underlying values. Do you recognize the value dilemma's below as distinguishing elements in the future visions? In other words: do you see the value dilemma's in the eleven future visions? In what way? Please explain.

Question 2: Do you think these patchworks of interventions correspond with your own values? (for each of them, see also Appendix F)

Additionally, the participants were asked to give their feedback on the co-design process as they experienced it in its entirety, through a 10-question survey.

1. What did you think of the co-design process as a whole?
2. What did you think of the results the co-design process delivered? Please specify.
3. Was the process informative? Did you learn anything new? If so, what?
4. Do you think the co-design process has any effect in the future? For example relating to coastal management? If so, what kind of effect? Why?
5. Did you feel heard during the co-design workshop round 1 and 3? In what way? Why? Or why not?
6. Did you see your contributions translated into the designs?
7. How do you value the contributions of the other participants? Of the disciplinary experts? Of the organizing research team?
8. If possible, would you recommend participating with another, similar process?

9. What did you think about the set-up at the location and the facilities provided during the workshops?
10. What is your most significant learning moment?

4.4. Concluding remarks and expectations

In summary, we designed a co-design process to address the specific case study situation of south-western Texel. The design choices that account for the requirements are summarized in the Table 4-2. The contextual specificity of southwestern Texel was important, as the content in each of the workshops is specifically geared towards Texel and the erosion issues near Paal 9.

The co-design process is designed to enhance shared understanding of the natural system complexity, the social system complexity and knowledge sharing. Local experts are to share their place-based knowledge, and experiences coming personal involvement on southwestern Texel in workshop 1 and 3. Experts from different disciplines are to share their expert knowledge about social, institutional and natural aspects southwestern Texel throughout the co-design process. The third workshop is designed to account for transdisciplinary knowledge sharing with all participants having equal voices and standing in validating the co-designed outcomes.

Special attention is paid to mitigating perceived authority by professional participants, by giving them different roles or tasks than the local participants, so as to ensure open discussions. Co-design workshop 2 and 3 both aim to provide opportunities to iterate on previous co-designed solutions.

Table 4-2 gives a summary of the design choices associated with the design principles from Chapter 2.

In summary, in co-design workshop 1, we expect that local participants are able to design future visions that are not necessarily feasible, but do represent aspects of what they want and do not want for their future and the island's future. We expect that giving the participants freedom and importance, will improve their engagement. We expect that local experts are able to assume the role of a key stakeholder group and vote accordingly. Additionally, local experts value learning formal knowledge about the coastal system. From the disciplinary specialists we expect that they present their work in an understandable way and be approachable to local experts needing to ask questions.

For the intermediate analysis of the values we expect that the voting behavior in co-design workshop 1 shows dilemma's in underlying values, e.g., certain stakeholder groups will value aspects that conflict with other aspects. Additionally, we expect that coalitions will not only be formed based on stakeholder interests, but also on underlying values. As a general underlying assumption is that calculating the Pareto optimum front is a suitable method to determine the value space, and simplify the spectrum of promising options.

In co-design workshop 2 we expect that the groups deliver feasible packages of measures for some visions for a specific coastal system. We expect that substantial time and effort would go into understanding the problem and the system, before

Table 4-2 Summary of design choices

	Identified principles	Associated design choices
P1	Include local knowledge and local values	Key component of entire co-design process
		Key component of co-design workshop 1 and intermediate analysis.
		Utopian and dystopian futures were co-designed, encouraging participants to envision over 50-100 year time horizons.
P2	Include scientific knowledge	Separation of the local experts and disciplinary experts, and giving them different roles in each of the co-design workshops, including advisory roles ('loketfunctie')
P3	Facilitate knowledge sharing	Key component of entire co-design process, e.g., through the 6-step process in workshop 1, by interdisciplinary teams in workshop 2, and through feedback in workshop 3.
		Plenary sharing of latest scientific insights on the bio-geomorphological system and its dynamics in workshop 1 and 2.
P4	Give local community and experts equal voices and standing	Power re-distribution by starting the process with the local experts
		Validation of designed solutions in co-design workshop 3
		Name participants local experts to underline their direct knowledge of the system
		Separation of the local experts and disciplinary experts, and giving them different roles in each of the co-design workshops.
P5	Account for contextual specificity and systemic complexity	Designs were to be physically realistic, but not constrained to current situation, so as to avoid current stakeholder interests or policy processes playing a dominant role ..
		Contextual analysis (ex-ante) on the social system, particularly the actor network.
		Contextual analysis (ex-ante) on natural system
		The location of workshop 1 and 3 on the island was specified to the area near Paal 9.
P6	Appropriate scope	Co-design workshop 1 and 2 focus on building a system view that encompasses the socio-economical, natural and governance contexts.
		Focus of the case study was relocated to the area near Paal 9, as there was a more visible and more urgent problem of erosion (as opposed to the Hors)
P7	Aim for transparency of relation with policy process	Experimental setting parallel to ongoing decision-making process, clearly and explicitly communicated to participants.
		Loose coupling of outcomes of stakeholder engagement process and decision-making process
P8	Aim for transparent research	Following TU Delft's Human Ethics Committee standards.
		Explicit communication that participants can leave the process and workshop at any time.
P9	Appropriate participant selection	Participant selection considerations included selecting unusual suspects, pre-workshop phone interviews and getting a diverse group of participants using actor network analysis
P10	Appropriate moment of citizen involvement	Community stakeholders are invited to join at the idea generation phase.
P11	Strive for a creative level of engagement practice	Co-design as a means to achieve a high level of stakeholder engagement.
P12	Strive for collaborative learning and building shared system understanding	Focus in co-design workshops 1 on identifying key factors of interest for Texel and the local experts.
P13	Avoid mismatch rationale and goals.	Transparent communication on scientific research undertaken objectives.

getting to the design phase. The professionals might tend to a narrow design space, thus focusing on one solution and disregarding other alternatives, but we expect that after a diverging phase, converging options are considered.

In co-design workshop 3 we test the assumption that the final designs will have considered the local stakeholders' values and suggestions sufficiently. Thus, we expect that participants are able to give feedback on the co-design process in which they participated. We expect issues with power dynamics, owing to the mixed group of local experts and disciplinary experts. We expect that we can mitigate those through clear discussion points and effective facilitation geared towards equality. Additional focus on feedback of the co-design process should also help, because the activity is something that no-one really experienced before. Moreover, participants are asked to give their written feedback individually, in addition to the oral discussion, to ensure every person gets a space to say what they want.

Results of the application of the co-design method are described in the next chapter.

CHAPTER 5

Application of a co-design process on southwestern Texel

This section presents the outcomes from each step of the co-design process applied in the primary case study as described in the previous chapter. We undertook a series of three workshops between December 2016 and April 2017. The content and process controlling input has been described in Chapter 4. In this Chapter, we analyze and interpret the results of the co-design process, reporting on empirical evidence and distilling observations.

5.1. Participant selection and attending participants

The participants in the three co-design activities are listed in Table 5-2.

Co-design workshop 1

In the first workshop, 17 local experts joined. The local experts have personal ties with the island of Texel and have specific, lived experience about this coastal system.

Table 5-1 The co-design process on the southwestern Texel case study, encompassing three co-design workshops

Activity	Co-design workshop 1	Co-design workshop 2	Co-design workshop 3:
Aim	Design future visions for the Texel coast. Focus on local experts' knowledge and values, transdisciplinary knowledge-sharing with disciplinary experts and their understanding of different facets of Texel's coastal system.	Collaboratively develop patchwork of interventions (i.e., coastal management strategies) by adding ecological, policy and engineering knowledge to achieve some of the visions generated in workshop 1. Refining initial designs from first workshop, based on stakeholder values, and checking for feasibility of future visions.	Assessment of proposed designs outcomes from the previous workshop(s), sharing insights of the research team and evaluation of the entire process, facilitation of strategic stakeholder conversations.
Tools	Workshop with local experts and disciplinary experts	Participatory design workshop with disciplinary experts	Feedback session with all previous participants
Date and location	2 December 2016 Texel	3 March 2017 Delft	6 April 2017 Texel

Table 5-2 Participants in southwestern Texel co-design process

	Local experts	Disciplinary experts	Support staff
Co-design workshop 1	17 local experts as primary participants, designing the future visions	4 disciplinary experts as information suppliers ('loketfunctie') and knowledge exchange participants	4 (2 facilitators, 2 observers and support)
Co-design workshop 2	0 local experts	14 disciplinary experts designing the packages of measures as primary participants	3 (1 facilitator, 2 observers)
Co-design workshop 3	12 from the 17 local experts returned	No disciplinary experts attended	2 (observers and support) 1 facilitator

An interdisciplinary team of six scientists from a variety of disciplines relating to coastal systems were invited to their share knowledge as needed. These included morphodynamicists, hydrodynamic modelers, ecologists concerned with the flora and fauna in the sea, the foreshore, and the beach-dune systems; social scientists and policy experts with knowledge of institutions and governance.

Co-design workshop 2

Present in the room were 14 disciplinary specialists with a stated interest in, specific knowledge of, and/or experience with coastal areas across the globe, including the Netherlands, France, Australia, West coasts of North America, South East Asia, Australia. The disciplinary experts are divided into teams, where diversity in discipline and length of career are considered. Disciplinary experts present were: water boards, coastal morphologists, geomorphologists, landscape architects, water board consultant, dune ecologists, policy scientists, coastal governance specialists (See also Appendix D).

Co-design workshop 3

Even though all people who participated in the first and second workshop were invited, twelve local experts participated. Unfortunately, no disciplinary specialist attended.

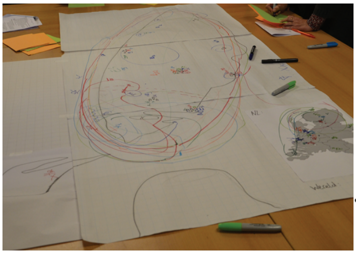
5.2. Co-design workshop 1: envisioning distant futures for the island in a collaborative setting

This section describes the results of the first co-design workshop that happened on 2 December 2016 on the island of Texel. The discussions and descriptions are translated from Dutch. In some places, we add the notions in their original language for clarity and comprehensiveness.

5.2.1. Identified key stakeholder groups

After consideration, nine stakeholder clusters were identified by the participating local experts.

STEP 1

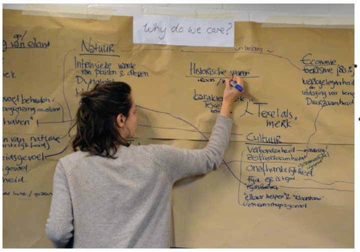


Getting acquainted. A map-based exercise in which everyone introduces themselves.

STEP 2

"Who cares?": Participants identify and organize key stakeholders in a group effort.

STEP 3



"Why do we care?": Participants determine key values and relations, to be structured in a plenary session.

STEP 4

Expert presentations on the abiotic and biotic systems surrounding Texel.

STEP 5

"What do we (not) want?" Participants design utopic and dystopic futures.

STEP 6

"What is important?" Participants vote on their preferred futures, taking on the role of a key stakeholder.

Figure 5-1 Six steps in co-design workshop 1

5

Table 5-3 Identified key stakeholder groups

#	Stakeholder group (translated from Dutch)	Includes (but is not limited to):	Stakeholder group (Dutch)
1	Sport & Recreation	Bird watchers, water sportsmen, surfers, “Ronde om Texel”	*“Sport & Recreatie”*
2	Nature & Landscape	Nature, scenery, flora and fauna, dynamics, seals, biodiversity	*“Natuur & Landschap”*
3	Traditional utilization or: “historic users”.	Fishermen, sheep farmers, bee keepers	*“Historisch mede-gebruikers”*
4	Cultural-historical	ReinforcingStrengthen Texel identity, beachcombers, village interest	*Cultuurhistorie*
5	Policy, Governance & Management	Defense, Municipality of Texel, Province, HHNK, RWS, “the politics”, Natura 2000, nature conservation, ….	*“Beleid, Bestuur & Beheer”*
6	Tourism (recreation from ‘the mainland’)	Beach cabin owners, traffic participants, Randstad people, nature lovers, tourist office	*“Toerisme (recreatie van de overkant)”*
7	Entrepreneurs	Entrepreneurs, camping owners, beach exploitation, diverse employment	*“Ondernemers”*
8	Inhabitants	The people of Texel, youth, citizens Den Hoorn, inhabitants of Texel, “us”, village committees	*“Bewoners”*

The stakeholder group ‘scientists’ were considered a key stakeholder group early in the discussion, as scientists observe the area from a scientific perspective. For example, the organizers and facilitators present at the workshop would be included in this stakeholder group. However, scientists as a stakeholder group were eventually excluded from the list, because the participants decided that it was an odd interest that was mostly, if not entirely, not influencing the bio-geophysical system.

5.2.2. Clarifying remarks

When we are identifying stakeholders and group them into key stakeholder groups, information is unequivocally lost. We nuance the categorization by the following observations.

First, fisheries are eventually categorized as ‘traditional utilization’. This group refers to stakeholders that traditionally have had a role in the local economy and includes shepherds. Thus, fisheries are excluded from the group of ‘entrepreneurs’ or ‘recreationists’. As such, they are considered separate from other economic users of ecosystem services, e.g., farmers, beachcomber, and others who enjoy nature and the sea, e.g., sailors, surfers.

Second, the participants made a clear distinction between ‘across the pond’ and people from Texel, living and/or working on the island. There are tourists (from outside) and locals, both enjoying the same nature, but distinctly separated in different key stakeholder groups.

Third, the non-harmonious relations between the different villages on the island that is rooted in different branches of Christianity was mentioned, but not thoroughly elaborated.

Fourth, the Dutch term 'landschap' is literally translated to the English 'landscape', and commonly refers to spatial use or planning, but can also have a connotation relating to aesthetics or spaciousness of the scenery.

5.2.3. Why do we care? Determining relevant values and relations

The overall picture sketched in the discussions of the plenary session mainly focused on key characteristics of Texel. Examples are the pitch black darkness during the night, which was contrasted with urbanized areas in the Netherlands; the good Texel food; and the connectedness among Texel inhabitants. Some mentions were almost poetic: the feeling of infinity, the sense of freedom, the ever-changing island that is Texel. Special mention was made of the rhythm of the daily life on the island, which is influenced by the ferry schedule that arrives and departs most working hours. Nature characteristics, such as the relation of the island with the sea and the intrinsic value of flora and fauna were mentioned in contrast with economic characteristics, such as tourism, agriculture and employment. One of the economic challenges for Texel lies in the aging population and a lack of returning Texel youth. Sustainability of the economic system is a goal, which was linked to a local approach; e.g., through local foods that emphasize the character of Texel.

Figure 5-2 presents the characteristics of Texel that were named, and how these characteristics were grouped. The figure shows that the participants built a system understanding of socio-economic, natural/environmental elements.

5.2.4. What do we (not) want? Collaboratively designing utopian and dystopian futures

Eleven visions were designed by four groups of local experts. Each group comprised four or five people, and was given a name of a bird species naturally occurring on the island of Texel. The groups presented their future visions in a 5 minute presentation, supported with drawings and maps. The table below gives a brief description of the futures.

5.2.5. What is important?

Each key stakeholder group was represented by two participants and received 6 positive and 3 negative votes in the form of stickers to be put on the designed visions affixed to the wall. Some 'creative voting' occurred, where participants put both positive and negative votes on the same option (i.e., 3B, 3H) to indicate some negative and positive aspects. Overall, two visions (G and K) can be considered unanimously positive (or neutral). Both these visions represent futures where human Texel and nature-area Texel exhibit balanced dynamic behavior. D and J received no negative votes, but less positive votes than G and K. Certain dystopic visions are unanimously or with large majority considered negative (e.g., E). Aside from war-like circumstances and climate threats, the nightmare-like visions also mention a lack of the Texel identity and colonization of the island by commercialism.

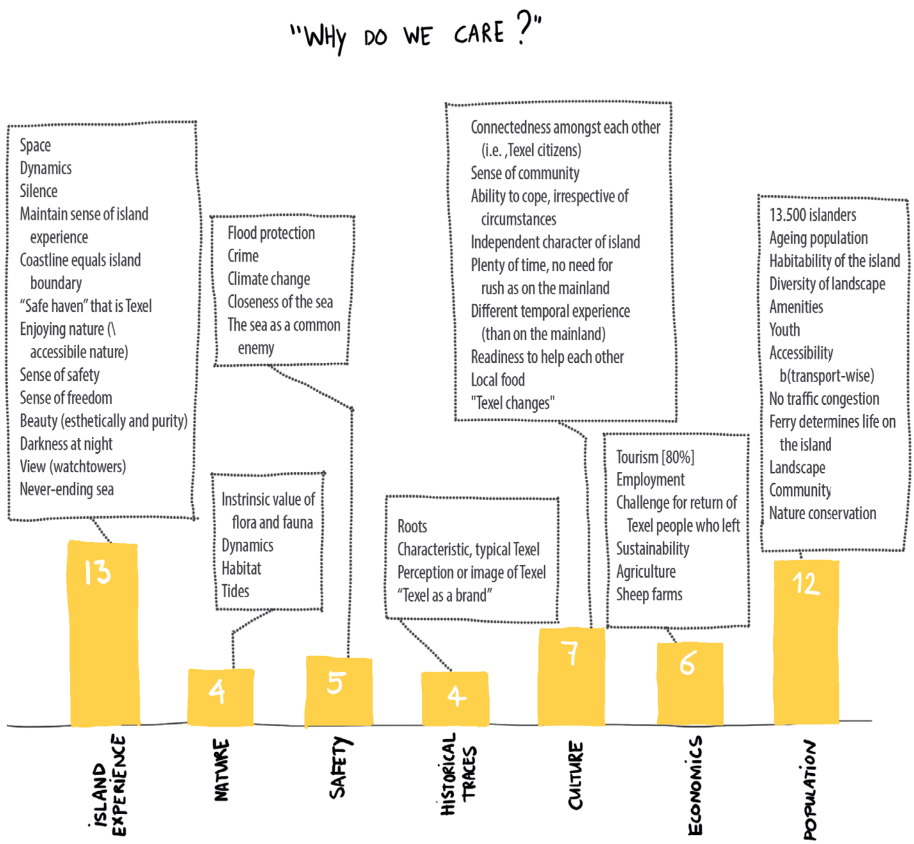


Figure 5-2 Perception categories of the island by participants, discussing the question: 'Why do we care?'

The participants also got the opportunity to comment on why they cast their vote on specific future visions.

Vision A received positive votes because it provided a lot of freedom for recreation and sports, in the sense that there is a lack of rules and regulation. Also, high tax incomes and lots of buildings and infrastructure were considered to be positive by the participants representing policy, governance and management. A motivation for negative votes was for example the marginalization of both nature and landscape.

Vision B was perceived to be positive because a lot was possible for sport and recreation, the future vision was harmonious with nature, the inhabitants found the vision recognizable, the vision is convivial 'gezellig' and attractive for tourism and all societal interests were served. The traditional users regarded the new ways of social welfare and co-habitation as positive, but did not appreciate the fake, kitschy history.

Vision C received one positive vote from the tourism stakeholder group. There would be a quiet and larger beach area.

Table 5-4 - Summary of the eleven future visions. Can be nightmares, others dreams, or realistic visions. Not all visions were indicated to be either one.

Future visions (A - K)	Group name
A) “Saint Tropez of the North” is a dystopian vision, where two bridges are to be built by the Texel bridge company TEBO. Texel will be a peninsula with a race track, wind mills, and an amusement park.	Peewit (Dutch: “kievit”)
B) “St. Texel” makes the Noorderhaaks, a large sand bank nearby, accessible, in the form of a lagoon with quiet water to swim. The southern edge of the island is larger, with playthings for the younger children, a grand horizon, a visitor center that fits in the landscape, and Hobbit-like dunes that evolve naturally.	Peewit
C) Realistic. A wide beach at Paal 9 and a pavilion in the dunes allows for more nature, and a small visitor center embedded in the dune. The Hors shoal will remain a beach plane.	Peewit
D) Texeltopia. Because of world peace, the defense residence will disappear. The Molengat will be a polder and the Razende Bol will be a new part of the island of Texel, just as accessible as de Hors. A larger Texel, with more natural areas, will have a positive effect on endurance and survival sports. Innovative entrepreneurship is encouraged.	Oystercatchers
E) DEBO Texel split in two. The northern side of the island will be cut off due to political turmoil. The war zone between north and south requires mediation from defense (in the center). There will be no room for own municipalities, Texel will be part of the municipality of mainland town, Den Helder. Only high-rise blocks and only day tourists who bring their own sandwiches (read: no income through services). Everything is the same, lack of quality, no hospitality and greying population all cause increased dependence on the mainland.	Oystercatchers
F) Texel International. The ebb-tidal delta allows for more sediment on the island. A port for the international jet-set will be built, with a beach plane functioning as a parking zone. The dunes will be covered with beach cabins. The tax free zone attracts the jet-set, there will be more housing near and on the sea walls. Airport Schiphol II is closeby, with routes to New York and London.	Redshank
G) Utopia: humans follow nature. The policy is “do nothing”: an adaptive management style. The people follow the lead of nature, which is a realistic scenario. The Razende Bol and the ebb tidal delta are naturally attached to Texel, no nourishments are required, neither signs, gates and fences. There will be a mobile pavilion and parking area. Education is key, a starting point for ranger safari and education centre is built. There will be room for monitoring and research. Core values include the lack of built environment: the beach pavilion will be moved. The first line of dunes will be decreased in height by human intervention.	Redshank
H) The 7 mills. Seven wind mills will be built on the Noorderhaaks, which will be enough to supply Texel with wind energy.	Redshank
I) Nightmare: high-rise block on the Hoge Berg. The sea level will rise and Texel will completely disappear, except for the Hoge Berg, where apartment blocks will be built. All will live together on this “terp-like” hill.	Curlew
J) Dream: flood Den Helder. A progressive dynamic coastal management style in Den Helder will result in the disappearance of Den Helder in the sea. Consequentially, the route towards Texel will be even better! There will be more sand and beach, quietness, no noise from Den Helder, and a better view. R.I.P Den Helder.	Curlew
K) Utopia: as natural as possible. Beach dynamics are natural, but we keep maintaining the beach and nature reserve. The net surface area of nature should remain the same over a time period of 10 years, albeit not in exactly the same spot. Den Hoorn should have a beach to exploit between Paal 9 and Paal 11. The school is closed already, because everyone young have moved away. We may allow for dynamics, because we already lost 1,5 km through inundation over the last 50 years, and that’s fine.	Curlew

Figure 5-3 Eleven future visions designed in co-design workshop 1

Table 5-5 Voting results for designed future visions (A-K) for stakeholder groups (1-8).

	Stakeholder groups (1-8)							
Future visions	1	2	3	4	5	6	7	8
A	1+	1-			1+			1-
B	1+	1+	1+ 1-		1+	1+		1+
C						1+		
D	1+			4+	1+		2+	1+
E	1-	1-		1-	2-	1-	1-	1-
F		1-		1-	1+	1-		1-
G	1+	3+	1+	1+		1+	2+	2+
H	1-		1+ 1-	1+				
I	1-		1+	1-	1-	1-	2-	
J	1+				1+	1+		
K	1+	2+		1+	1+	2+	2+	1+

Vision D received four positive votes from the stakeholder group representing traditional utilization, which was motivated by maintaining of the 'own': (i.e., traditional Texel) values. Sport and Recreation considered the future vision to be beautiful, entrepreneurs casted two votes because of the attractiveness to the youth, and the inhabitants valued the freedom. The participants representing stakeholders related to policy, governance and management unfortunately did not give motivation. We hypothesize that the attention for the local economy and tourism were influential to their positive vote.

Vision E – perhaps unsurprisingly - received negative votes from almost all key stakeholder groups. Motivations included "SHIT", and "CRYING", and "No War". Even the entrepreneurs voted negatively, motivated by the lack of economic opportunities in this divide-and-conquer scenario.

Vision F's modern character, lack of space for nature, unattractiveness to current tourists and cultural poverty resulted in a negative judgment of most key stakeholder groups. Only the participants representing policy, governance and management-related saw a shimmer of positivity in this scenario, which is mainly financial in nature: many buildings, much tax income.

Vision G also received only positive votes from all key stakeholder groups, except for the group representing policy, governance and management. Positive aspects included the priority given to nature and nature development, the accessibility of recreation areas, and the awareness of oneself and one's surroundings in this future vision. Tourists would be attracted to the area because of the quietness, and entrepreneurs considered the modern and innovative approach for the current target group interesting.

Vision H received varying feedback. The lack of accessibility of the Noorderhaaks to the public was considered to be negative by the sports and recreation group. The cultural-historical stakeholder group appreciated the use of the area as kite area. Traditional users were ambivalent: the irrevocability of the terminal and the auctioning of morality (Dutch: 'verkoop van moraal') were considered negative, whereas writing new history and the braveness of the design were considered positive.

Vision I was judged quite negatively. Only the stakeholder group representing the traditional utilization found a positive note: living on a man-made hill resembles a historical 'terp'. where people moved their cattle and build their farms in case of floods. Lack of (public) space, disappearance of the island, the densely built area and the lack of entrepreneurial and economic opportunities were all reasons to vote 'no'.

Vision J was considered positive by three stakeholder groups. The space for sports and recreation, the disappearance of Den Helder and the aesthetic attractiveness of the route to Texel were all considered positive. It should be said that this designed future vision, as well as the accompanying positive votes, are interpreted as a (perhaps typically Dutch) expression of light-hearted, sarcastic humor. The subtle underlying message refers to rivalry between Texel on the one hand and the mainland and Den Helder on the other. So, wiping out a neighboring town is not considered to be a real solution by anyone. However, the positive attributed values: more quietness, aesthetics of the scenery, lack of light pollution et cetera are real aspects to be strived for.

Vision K received only positive votes by all key stakeholder groups aside from the traditional users. Conserving the Texel character ('Texel remains Texel'), conserving nature, and conserving recreation areas were all reasons to vote positively, the tourism and the cultural-historical group, nature & landscape, and sport & recreation respectively. The participants representing the group policy, governance & management remarked that policy making in this future vision is possible. Inhabitants valued the natural character of the future vision.

5.2.6. What did we learn?

Overall, direct, plenary feedback on the experience of participants was positive. As for the workshop process, participants indicated that when the stakeholder groups were made, participants did not realize that this step was quite important for the end results. Participants were also wondering about the replicability, as the designs would be different, but maybe the underlying values might still be similar. It was appreciated that the organizers also did not know exactly where the day and the designs would go. The personal approach of telephoning to invite the local experts was widely appreciated, as was the prominent place for local knowledge and using the islanders' connectedness. Local experts appreciated the knowledge input they received from the disciplinary specialist, as they have different perspectives when looking at Texel and its surroundings, and they helped create an enthusiastic, friendly and collaborative atmosphere in the workshop. All in all, most participants hoped they could participate more often in co-design exercises on different topics related to Texel.

We feel that the trust of participants in the 'neutral' organization of the workshop (i.e., not affiliated with policy makers or other actors with interests) was a contributing element in the success of the workshop, as it contributed in an open dialogue between different participant groups.

As an additional side-note, we noticed that the future visions from workshop 1 were expressions of light-hearted, sarcastic humor. It takes an observer with specific knowledge of the local culture to interpret the subtext and other implicit communication. By doing this, we realized there is always the risk of missing such subtexts in future observations. However, we are convinced that the material was interpreted properly, and that our analysis is transparent about our interpretation.

5.2.7. Interpretation of co-design workshop 1

Here, the co-design workshop 1 is summarized and characterized in terms of the theoretical promise of design-oriented activities in the coastal context.

Natural system complexity

The focus of co-design workshop 1 lay on collaboratively designing utopian and dystopian futures. Participants were encouraged to envision over 50-100 year time horizons. The designs were to be physically realistic, but not constrained to the current situation. Accordingly, the designed future visions sketched images of possible futures that would require changes in the bio-geophysical system. However, geomorphological and hydrodynamic influences on the coastal system were not considered by the participants in designing their visions. The visions showed consideration of deeply uncertain factors such as climate change and sea level rise, and their potential impacts on Texel.

Social system complexity

In this co-design workshop, the activity of building shared system understanding among participants led to rich discussions, appreciation of different viewpoints and appreciation for the collaborative activity itself. As participants stated in their feedback, they appreciated that the local knowledge and local expertise was taken seriously and respected. They learned this from how the process initiated, as well as in introductory talks with the organizers. Several times, the discussions moved from the bio-geophysical system knowledge to the character of Texel. The main focus points for the designs were how any proposed changes would affect the socio-economic subsystems. In other words, changes in and the effects on the living environment of the participants were considered the most.

Additionally, participant selection resulted in a group of 'unusual suspects' and, according to some of the participants, new faces. This is indicative of individual learning on the actor network of Texel island.

Knowledge sharing

Four people were present as disciplinary specialists, in professional capacity, and each of them had disciplinary expertise on the coastal system of Texel. These participants supplied information and advised where possible and when necessary, sharing with participants their knowledge on abiotic, biotic and institutional aspects of the coastal systems. Participants explicitly appreciated the co-learning, noting that learning from scientists on the Texel environment from different perspectives made their participation worthwhile. Additionally, the local experts shared their own contextualized knowledge and lived experience on the coastal system of southwestern Texel.

The spatial bounds of the designed future visions matched the living environment of the participants well, and were limited to the island of Texel, Noorderhaaks, and Den Helder.

5.3. Value space analysis and interpretation

The analysis uses the future visions and their ratings to assess the extent to which the values of the interest groups are represented in the outcomes. The analysis step was performed by the organizers together with Prof Cunningham between the first and second workshop (see Cunningham et al., 2014; Kothuis et al., 2014; Slinger et al., 2014). To analyze the designed future visions and their ratings in the first workshop, and to identify potential social dilemmas, we mapped the design space using Pareto optimum front analysis. It is important to note that the analysis delivered another, first value dimension, which is left out of the analysis and the scree plot, because it explained near-all voting behavior, and thus did not show any dilemmas.

The scree plot (Figure 5-4) is a line segment plot that shows the percentage of total variance in the voting behavior (y axis) as explained by each principal component, or 'eigenvalue of the matrix'. We examine the scree plot to get an idea of how high-dimensional the data is. In this analysis, we decided to call the principle components 'value dimensions', for communication purposes. Read the plot from left-to-right to determine where the 'most important' value dimensions cease and the 'least important' value dimensions begin. The value dimensions are sorted in decreasing order of variance. In this case, the scree plot shows the proportion of variance for each value dimension, and while we see that the highest dimensionality is 8, there is

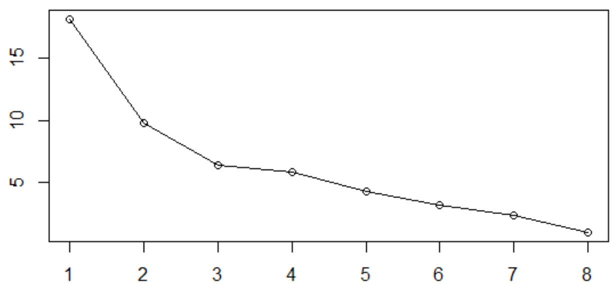


Figure 5-4 The scree plot shows that value dimensions 1 – 4 cumulatively explain the most voting behavior.

a clear inflection point around 3. The first three value dimensions are considered to be the most important, as they cumulatively explain 67 % of the variance in voting behavior.

Next, we analyze the alignment of interests between the stakeholder groups, so as to identify and interpret potential value-based coalitions. A broad space of agreement about the desirability of outcomes often exist among stakeholder and interest groups. The coalitions of interest groups that want consistently the same things were identified. The first coalition is basically the grand coalition; all stakeholder groups are on-board except the stakeholder group traditional utilization (group 3, Table 5-3). The second coalition is basically the stakeholder group on Nature and Landscape, and the inhabitants (group 8). They see themselves as stewards of a relatively untouched, undeveloped place. This second coalition is opposed by businesses and entrepreneurs (group 7), whose commercial interests align with wanting to increase economic activity and tourism. The third coalition is historical and recreational in character and includes Sports & Recreation (group 1). This third coalition is opposed by cultural interests for reasons unclear to us.

Interpretation of this part of the analysis led to the construction of three value dilemmas. Table 5-6 shows the dilemmas as we interpreted them and communicated to the participants in the next workshop (co-design round 2). The first value dilemma positions dynamic nature on the one hand, against maintaining traditional landscape and cultural history on the other. Where nature has free reign, the man-made and man-used landscapes on the island of Texel have to go, and vice versa. The second value dilemma positions the capitalist understanding of commercial mass recreation, in which the money that can be made from mass tourism, and the associated independence, also makes the island dependent on the tourists. This conflicts with the Texel identity of being self-sufficient and the stewardship of the island. The third value dilemma is similar to the second, where the entrepreneurial mindset of Texel is in conflict with dependency on the mainland and on the national government, and the interference of policy measures coming from the national, provincial and regional authorities.

Then, we analyze and interpret the issues underpinning the voting behavior. The future visions two islands and 'high-rise block on the Hoge Berg' (vision I) and 'DEBO Texel split in two' (vision E) are clearly dystopias: almost everyone views

Nature and dynamics	⟷	Landscape and cultural history
Texel identity, "own use"	⟷	Commercial mass recreation
Texel entrepreneurial mindset, self-reliance	⟷	Regulation and governance, dependency on the mainland

Table 5-6 Value dilemmas. The social dilemmas associated with options that conflict each other when envisioning futures for the island of Texel.

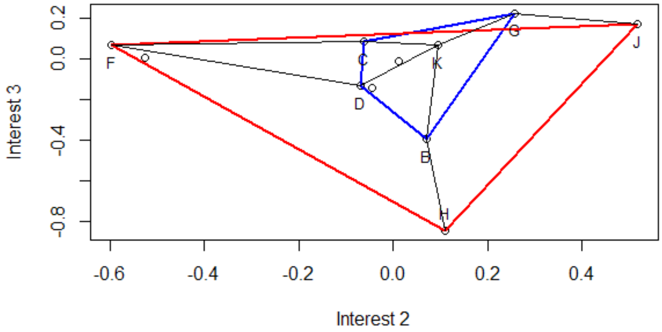


Figure 5-5 Plot. This three-dimensional plot enables us to examine the visions in light of the value dimensions. The plot is a similar to a pyramid, looked at from the top (blue) to the bottom(red). The plot shows a clear distinction between the utopian visions (blue) and the dystopian visions (red), where vision C ('Realistic') is in the middle.

these as going against the common interest. The second issue is characterized by their high level of contested visions: the visions 'Saint Tropez of the North' (vision A) and 'Texel International' (vision F), opposing 'high-rise block on the Hoge Berg' (vision I). The third issue is mainly embodied by 'the 7 mills' (vision H) and 'St. Texel' (vision B).

The analysis of the Pareto optimum front (Figure 5-5) shows us that there is a single Pareto-optimal point somewhere between the visions G and K. However, the value are such that you may get different designs depending on who is part of the design process. The results of the Pareto front give rise to the question whether it is possible to generate a socially robust solution in the space near the utopian visions G, K and D. Socially robust decisions would leave few options for single actors to change to another options and win, i.e., the current option is the most optimal one in that part of the value space.

In this intermediate analysis, we examined whether social dilemma's existed (i.e., situations where individual self-interests result in outcomes which leave everyone (else) worse off). The gaming element that was the foundation for the input data of the Pareto analysis may have affected the outcomes. Indeed, voting participants did not vote according to what they believed, but they voted according to what they believed others valued. Interestingly, this may have come out in the voting behavior. For instance, future vision F had a modern character, lack of space for nature, unattractiveness to current tourists and cultural poverty resulted in a negative judgment of most key stakeholder groups. Only the participants representing policy, governance and management saw a shimmer of positivity in this scenario, which is mainly financial in nature: much to build, and a lot of tax income. This gives rise to the question whether this is indeed how these participants see the government and governmental values. Moreover, this can be interpreted as a cynical view of the government, which may or may not be aligned with reality, and subsequently may skew the results of the Pareto optimum front.

In conclusion, this analysis suggests that there is indeed a shared, broad value space. Different expressions of the value dimensions are manifested in the various designs about the future of Texel. The co-designs of the future visions designed in workshop 1 encompass some of these expressions (see also Appendix C). We ask the participants in co-design workshop 2 to find new, and more optimal, expressions of these values.

5.4. Co-design workshop 2: designing with disciplinary experts

In the second co-design workshop, fourteen disciplinary experts co-designed in teams (see Appendix D). Figure 5-5 illustrates the newspaper and article titles that were part of the converging exercise. This section describes the co-designed outcomes of co-design workshop 2, and its analysis and interpretation.

5.4.1. The designs: patchworks of intervention measures for coastal management strategies.

The groups chose to present the patchworks of intervention measures and the reasoning behind their choices to each other, both orally and supported by drawings and maps. Then, the participants commented and discussed each other's work. In this section, the proposed patchworks of interventions are described, followed by a summary of the discussion points that came up after each presentation.

Patchwork of interventions designed and explained by group 1

Summary. Group 1 created two alternative designs for coastal management strategies. Both entailed the creation of salt water intrusion in a dune valley ('zoute duinvallei'). They considered a time-scale of 30 years. The two options were called 1) Man follows nature ('Mens volgt de natuur') and 2) Manage nature.

Basic assumptions. This group considered a few aspects in their brain storm session, notably the time horizon of their designs. They designed two contrasting visions: 'Man follows nature' and 'manage nature', with as points of departure the future visions that came from co-design workshop 1.

Patchwork of interventions designed by group 2

Summary. Group 2 went for a coastal management strategy that allowed for a lot of natural dynamics. Allowing for natural dynamics ('doing nothing') on the beach has advantages and disadvantages. Infrastructure should be re-developed to allow for more flexibility, and also the pavilion and beach huts can be designed to have a more 'pop-up' character. This asks new insights from scientific and technological fields.

Basic assumptions. This group made one package of intervention measures. The focused on the wish lists of the utopian future visions that were developed in workshop 2: G: 'Humans follows nature' and K: 'Utopia: as natural as possible'. Additionally, they considered the natural development aspects of scenarios B ('St. Texel) and C ('Realistic'). See for a description of these earlier visions Section 7.2. A key question for Group 2 was: what will happen if we do not intervene? The erosion

Figure 5-6 Illustrative selection of headlines of news and scientific journals.

phase around Paal 9 (southwestern Texel) will be followed by a period of accretion in 25-50 years. Until then, we could lose 200 meters of land. Such a loss of land will not have any consequences for the water security. However, it will affect the natural values in the area. Additionally, not intervening will result in cost savings for coastal management, which in turn may be invested elsewhere.

Patchwork of interventions designed and justified by group 3

Summary. Group 3 (Figure 5c) chose to design from the more realistic visions. They used the unique dynamic character of Texel as point of departure, both spatially as socially. The southwest part of Texel is characterized as being different in character than the other parts of Texel, which should allow for a different approach when intervening in the physical system. As a social intervention, group 3 suggests organizing a fund (TEZO: Texel's Eigen Zand Onderneming), where inhabitants of Texel allocate the budget for sediment nourishments and coastal management as they

Patchwork of interventions designed by group 1 (see also Appendix E)

Option 1: Man follows nature. We create a brackish dune valley environment (Dutch: *zoute duinvallei*) from the Mokbaai. The saltwater intrusion creates a different landscape with a valley-like landscape. Because of the inherent dynamic character of such an environment, the recreation, the camping and the playground(s) get a 'pop-up' character. There is plenty of space left to fill in the nitty gritty details of this designs, following the principle Suit Yourself (Dutch: 'Zoek het lekker zelf maar uit ja'). The time horizon spans 30 years, which opens up prospects for the degree of natural dynamics in the area.

Option 2 Manage nature. This option proposes the same brackish dune valley environment as in 'Man follows nature' and the same time horizon (30 years). Recreational facilities such as a Landal (commercial) winter park with a swimming pool will be placed in the area to allow for more recreation, also in the winter season. The Noorderhaaks will be changed and the *Razende Bol* will become a *Razende Duin:* through dune grass planting the Razende Bol will be fixed. Communication and education is necessary in the area, as are adjustments in law and regulation, such as for example the 'Legger', an official register that prescribes the spatiality of, in this case, coastal defenses (e.g., dikes, dunes).

Time horizon. The geo-morphological time horizon comprises 30 years. The hotel and catering industry and the municipality work in shorter periods of time, probably less than 10 years. The natural dynamics in the area, particularly the brackish dune valley environment, is sensitive to seasonal influences.

Nature values. The brackish dune valley environment creates a new scenery that is relatively rare for the island of Texel. An impediment to the success of the brackish dune valley environment may be that the current legal status of the area needs to be changed. Furthermore, it will take a while before the brackish dune valley will be considered 'attractive' and beautiful. This needs to be reckoned with, e.g., in communicating with tourists and inhabitants of Texel. The focus in these designs lies on the natural areas: the hotel, catering and recreational industries are not really considered.

Discussion points on work of group 1 focus on the technical and social feasibility of the proposed design. Socially, changes on the island are always difficult to impose. From the technical point of view, the question arises on whether a saline (or brackish) dune valley environment could be created. The salt water would have to come from the Mokbaai, because retrieving salt water from the other side would not work. Additionally, recent experience shows that it will take a long time before such an environment becomes pretty.

Patchwork of interventions designed by group 2

Dynamics and beach width. The group designed a dynamic buffer zone, which will disappear in more than 25 years. The reasoning behind this involved the accretion phase that will probably start in 50 years, the pavilion has to be so mobile that it can be relocated close to the sea. In the current situation, the beach is too narrow. Wider beaches are necessary to stimulate 'blow-outs', just as more gentle inclines of the dunes slope, windblown sediment and dynamic dunes. This behavior can also be manually stimulated by removing grasses and excavate sand. Can we intervene to stop erosion and advance the period of accretion? Actually, eroding coasts inhibit many natural values and bio diversity. Advancing the start of the accretion phase is that they will lead to influx in the dune systems.

Infrastructure and mobility. Currently, the problem is that there is a too narrow beach on a specific location (i.e., near beach pavilion Paal 9). Why don't we relocate the entire 'cluster' of facilities southwards? The accessibility problems that then will arise will have to be overcome with mobile infrastructure.

Investments pavilion and beach huts. The saved costs will be spent on the (semi)-permanent and seasonal facilities in the area. Beach pavilion Paal 9, which will be a mobile pavilion. We will prescribe a certain floor level for the pavilion for the next 5 to 10 years. The higher the pavilion, the longer the location remains suitable. We propose a yearly changing location for the beach huts: but that has to be somewhere on the beach. The hobbit-like dunes will be used as inspiration for a to be designed visitors center. Not on the Noorderhaaks, as was an element of some utopian future visions, but on the island. The design of the beach huts will also be reconsidered, so as to fit them better in the surrounding landscape.

Points of special interests for the fields of science, technology and engineering. Additionally, new designs are required for 'pop-up infrastructure' and mobile pavilions. Communication about time horizons and will be the spearhead of the communication program.

Discussion points for the design of group 2 during and after the presentation. Aiming to accelerate the accretion phase is nice, but there is actually a lot of natural value present in an eroding coast, because it leads to influx in the dunes that lie behind the beach. An estimate (quantitative predictions) of the morphological developments are necessary. Additionally, even though beach erosion at this part of southwestern Texel is not detrimental for flood protection, local people will not experience it that way. The narrower beach, created by letting go of the current sediment nourishment program, may result in a decreased sense of safety with inhabitants and tourists, even if the flood protection level is factually still intact. As such, any solution that incorporates beach erosion will minimally have to attempt to overcome that with a communication plan, for example by explicitly addressing changing dynamic processes on longer periods of time and the dynamic nature of the Wadden islands.

Patchwork of interventions designed by group 3

Choices. Group 3 came up with a short-term and a long-term solution. The short term solution is a local-scale one, and described as a sediment-feast (Dutch: 'zandbanket'*)*, in which the beach is widened and more natural dynamics are allowed by lowering the first (outer) dunes on south-west Texel. In this solution, getting a surplus of sediment in the dune system of South-west Texel will be accomplished by adapting certain legislation: changing the BKL (base coast line) and re-determining the desired cross section of the dune, i.e., lowering the outer dunes. This solution would involve relocation of the beach pavilion Paal 9 and the beach huts, stakeholder management. Additionally, monitoring of the coastal profile (*Dutch: kustprofiel)* and any hard structures are of importance.

The short-term solution may be combined with the long-term solution, which affects a larger scale. The second solution aims to accelerate morphological development on the long term, by dredging a *kortsluitgeul* on the Noorderhaaks. The temporarily released sediment surplus will benefit the sediment feast of the short-term solution. This solution would be financially cost neutral. How? First, the group proposes to start a fund will be started: *Texels Eigen Zandonderneming (TEZO)* (a wordplay on the publicly owned ferry company), which will be a public-private initiative in which inhabitants of Texel participate themselves. The leading idea is here: Do It Yourself (DIY, i.e., local influence). The inhabitants of Texel will determine where the sediment budget, possibly supplemented with income from the ferry, will go. As Texel inhabitants will know what is best for the island, and as such can determine the budget that became available out of savings in sediment nourishment expenditures. Would they like a wider beach? Do they want to relocate the beach pavilion? Do they want to dig a channel in the delta outside the dikes (*buitendelta*) to stimulate sediment accretion?

Effects. The long-term solution would change many things on the institutional side. Interventions in the physical system are only possible with adjustments in law and regulation. The dredging of the *kortsluitgeul* and the changing dynamics on the beach-dune system require monitoring the sediment flows and beach width, as well as (renewed) institutionalization of the new beach pavilion and beach hut locations. On the social side, stakeholder management is key in the success of either option. Additionally, the TEZO-fund will be tied to rules of the game: who are going to decide, how, and under what conditions and restrictions. The rules of participating in TEZO would have to be drawn up.

Plenary discussion points for group 3. Entering into a public-private partnership such as TEZO is a way to democratize the issue of balancing the costs of coastal management for which purpose. The question is, is this process not democratic enough already? And how much relinquishing of power and influence to local inhabitants is desirable?

Patchwork of interventions designed by group 3 (continued)

Indeed, participants may not have enough knowledge to make informed decisions that affect their island in the long-term. Indeed, the challenge might lay in convincing stakeholders, and not in a technical solution or a lack of system understanding. Also, this social solution is sensitive for government authorities, as it would create different sets of rules for different actors.

A dynamic and adaptable approach is desirable, as the timing of periods of accretion and erosion is uncertain. Intervening on the ebb-tidal delta would indeed require changing regulations. The dilemma between physically intervening in the system by landscaping versus letting go and allowing for natural dynamics is clear.

see fit. This would require institutional changes in laws and regulations, 'rules of the game' for the TEZO, and monitoring programs of e.g., the sediment flow and beach width.

Basic assumptions. This group remained close to the future visions of workshop 1 that were utopian (G and K) that were more realistic in nature (e.g., C 'Realistic'), but considering and incorporating the feeling of struggle of the local Texel inhabitants. The group perceived a clear distinction between the South-western part and the rest of the island of Texel. The South-western part is different in terms of natural values, and is also quieter and less cultivated than the rest of the island surface. Secondly, the group aimed to include the unique dynamics on Texel, both socially and in terms of scenery, which would involve that the sediment from the Razende Bol will arrive on the beach eventually. The question is: when? Looking at the map of Texel, the southern part is characterized very differently from the norther part in terms of natural values, which should allow for a different approach when intervening in the physical system. A third starting point is that the involvement of the local communities ought to be maintained.

5.4.2. Feedback from the disciplinary experts during a plenary discussion

In a plenary session, the participants are asked to discuss each other's and their own patchworks of interventions, as well as the workshop day as a whole.

Workshop design. Getting acquainted through drawing a map functioned as an ice breaker, and an effective way to get to know each other (and each other's expertise). Additionally, the participants appreciated the lighter activity (making the news headlines) which got them out of their tunnel and opened discussion between the teams. In hindsight, these headlines could have been emphasized better.

Completeness of expertise and knowledge present. Participants noted that the ecologists and the 'real' nature-lovers were missing, and there could be more landscape architects and spatial planners present. Someone noted: "We need people who not always think more sand is a good thing". Participants felt this missing knowledge also showed in the deliverables. Additionally, the recreational options that were thought of were very dependent on the disciplinary knowledge of the participants. Also, the legal and institutional aspects of the designs, required a legal person with expertise in the application of ecological laws (i.e., Natura 2000).

Group composition. The group arrangement worked out effectively and guaranteed that multidisciplinary teams were formed.

Informative presentations and other input. An expert suggests that the way the information was designed, might have had an effect on the outcome. Someone mentioned that the used approach was interesting, but the discussion of the methodological side, especially the value dilemmas, was difficult to understand and not everyone could make sense of it. Perhaps there was also too much emphasis on the methodology of the entire thing. On the other hand, without this emphasis on the approach, the participants might not have understood how we got from the colorful chaos on the wall (referring to the co-designs from the first workshop and the votes) to the value dimensions. The booklet with written information on earlier co-design workshops, especially the appendix with the votes was very useful. Unfortunately, a few participants did not realize it was there.

Self-reported design process. In addition to the design methods, tools and supplies that were chosen, there might be use for good interactive models (which some participants had some experience in). Other things that were mentioned to add in the design toolbox: clay, or a sandbox, or magnetic sand, to allow for 'sketch' in three dimensions. The different design groups took various approaches in this assignment. Group 1 reported that they focused on the designs as defined by the stakeholders. They designed according to the principle (or: the value) to keep everything as natural as possible. Group 2 started off with a discussion on how the system works and how it should be done. This discussion provided the foundation and inspiration of the team. After the lunch break, the group had a brainstorming session to sort out the solution. Group 3 used two points of departure: the ebb-tidal delta channel and the local stakeholder values. They focused on the posters on the wall during the designing phase, and not as much on the value dimensions that were explained in the informative presentation.

5.4.3. Interpretation of co-design workshop 2

Natural system complexity

The designed packages of measures proposed innovations in the physical system, with consideration for potential adaptations in law and regulations. The representation and the level of detail for the natural system varied across the subsystems, and not all necessary elements were represented. However, the interlinkages were explicitly considered by all co-design groups. The designed packages of measures considered the system in a wide temporal horizon (30 to 50 year), for which the geomorphological influences on the natural system southwestern Texel are uncertain, especially when and how much sediment will be deposed on the sandy shore. Additionally, changing climatological influences may affect Texel in unknown ways. The co-design workshop did not allow for extensive research modeling and experiments how dynamic processes are steerable in the natural system. Accordingly, the co-design packages of measures exhibited a limited level of detail for the effects in the bio-geophysical system, and were designed to allow for future adaptations. This posed requirements on law and regulations, especially for the physical measures that were designed to be flexible and adaptive.

Social system complexity

As was requested from the participants, the designed packages of measures additionally proposed innovations that linked to the policy context and the socio-economic system elements, and demanded changes in institutions between municipalities, water boards etc. This would require process and/or institutional design elements in the co-designs. Knowledge of and on relevant actors and stakeholders were represented in part by the designed future visions that were the outcome of co-design workshop 1. Thus, knowledge of the existing actor network complexity on the island was present in the room. Consequently, actor network complexity was referred to repeatedly in the designs. For instance, when discussing safety and security issues, the importance of communication to the (local) community was stressed, as the participants felt that emotional attachment to security will influence stakeholders in decision-making processes. As such, contextual factors of the social system influenced the co-design in workshop 2.

Knowledge sharing

In co-design workshop 2, interdisciplinary groups of experts were tasked with designing feasible packages of measures. Input from co-design workshop 1, most notable the designed future visions for Texel, but also the value dilemmas enriched later discussions among professionals about intervention strategy alternatives. Shared findings included that "the challenge is not the technology, because physical solutions are already here." Instead, the challenge lies in the social system (i.e., are process and institution related), which was reflected by the co-design and the discussions during the day. The designed packages of measures also reflected consideration of long time horizons and appropriate spatial horizons. .

Knowledge sharing occurred extensively, for instance through discussion and advising among the interdisciplinary experts. Knowledge input from the local participants came only in the form of the co-design from workshop 1, and from the results of the intermediate analysis. There was no additional input from them during the workshop.

5.5. Co-design workshop 3: validation and feedback session

The third and final workshop was conducted on 6 April 2017 in the afternoon. In this workshop, earlier participants of the co-design process were invited to give feedback on co-designs and the co-design process.

5.5.1. The activity

As mentioned before, all participants that attended one of the earlier workshops were invited for the last workshop. The purpose of the third workshop was to check for quality of the output of the second workshop, and to reflect on the co-design process as a whole.

Even though all people who participated in the first and second round were invited, twelve local experts participated. Unfortunately, no disciplinary experts attended. Participants' memories were refreshed and they were informed on subsequent

Table 5-7 Participants ' validation on the patchworks of interventions that were the output of workshop 2. "Do you think these patchworks of interventions correspond with your own values?"

Group #: Name of patchwork of interventions	Average rating (1-5)	Median rating (1-5)	Selected feedback quotes from participants, positive (+), negative (-) and neutral (0), providing reasons for the grade.
Group 1: Human follows nature (group 1)	2,7	3	+ Considers the flexible location of human use 0 Sounds good, but there are concerns about safety - Too disruptive, too commercial, too massive - Too much emphasis on human interventions - Too much input from engineering and technological innovations, and disregard for the Texel identity and Texel approach.
Group 1: Manage nature	2,3	2	+ 'Helping' nature and stabilizing the coastline through encouragement of natural processes in a smart way. 0 Should be named: human helps nature when necessary - Nightmarish! too commercial, a bungalow park is in contrast with values of Texel.
Group 2: Dynamic buffer zone	4	4	+ The solutions balances nature and, recreation nicely. + This is a realistic image of how to let nature take its course with minimal invasion. 0 Texel inhabitants want a wider beach, but don't realize how that is realized. 0 Challenges lie in communicating to inhabitants and tourists, as well as translation in laws and regulations. - Concerns about safety buffer (i.e., sand volume, beach and dune width) - too long time scope (10 years is already long for zoning planning, let alone 30).
Group 3: Unique values south-western-Texel	3,5	3,5	+ Essentially a good idea. However, financing is a challenge, in that money should be used for other ends. 0 Most habitants do not have enough knowledge to make an informed decision. - Nightmare scenarios: artificial, even though the island is perceived as natural. - Scientists and engineers keep creating, but they are not informed about how things are locally. They should consider local people more seriously.

design steps through a 20 minute presentation looking back on round 1 and 2. The characteristics of the patchworks of measures designed by the disciplinary experts were discussed as well.

The co-design workshop 3 occurred at Strandpaviljoen Paal 9.

5.5.2. Local expert validations of the design iterations

In the workshop, participants were encouraged to validate and reflect on the outcomes earlier in the process. The findings are presented in Table 5-7. The participants recognized for instance some misinterpretation of stakeholder values. Additionally, they found that the disciplinary experts took their input not as far in the next iteration as they would have hoped. The participants partially recognized the value dilemmas, and moreover, they felt included and appreciated in the process. Results and answers of the 12 respondents are presented in Table 5-7.

5.5.3. Discussion and interpretation of co-design workshop 3

Co-design workshop 3 served as a validation session, and as such, is not interpreted on the basis of the theoretical promise.

Overall, the respondents valued the co-design process positively, judging it interesting and informative. All of the participants would be joining again. Some respondents (e.g., #10) mention they felt empowered to join further in decision-making processes, feeling they can contribute substantially to the policy making process. Learning occurred through the formal knowledge, e.g., through the presentations on the geomorphology of the area by disciplinary experts in workshop 1. Others mentioned (e.g., #8) that learning of each other's and other stakeholder perspectives was quite valuable. The fact that participants were not the 'usual suspects' was noticed and appreciated: Some participants included faces that normally do not participate in the participatory meetings.

The participants declared that the co-design process specifically, and more collaborative design processes in general are useful tools for developing future policies. Where they felt that common stakeholder consultation often felt like they were invited 'too late at the table', or 'too early' ("That has already been decided upon" vs. "That is a question we cannot answer yet"), they felt in this co-design process included and their inputs valued. Also, the enthusiasm of the organization was widely appreciated.

Substantially, the designs that resulted in packages of coastal management strategies for the future of Texel were not really surprising according to the participants.

In the co-design workshop 3, we saw that the disciplinary experts could not attend. This may be partly due to scheduling conflicts, and partly to the time it would be to get to the location for most experts (who live on the mainland). The tourism dominated island economy did not allow for re-scheduling or re-locating. Although unplanned, the changed group composition allowed us to slightly adapt the discussions, and perhaps resulted in a more open discussion. Indeed, the expected issues concerning power dynamics in the group discussions were avoided (Section 4.4). However, we missed shared disciplinary knowledge sharing. Moreover, local experts' responses indicated they perceived the absence of disciplinary experts as a signal f the 'authorities' not caring enough to attend and Texel not being a priority for them.

5.6. The primary case study: conclusions, discussion and reflection

This chapter discusses the results and draws (preliminary) conclusions about the Texel case study. The case study of southwestern Texel describes the use of a qualitative co-design process to support the envisioning of futures for a unique coastal area of the Netherlands. We aimed to explore how transdisciplinary, collaborative design can serve as a point of departure for coastal management interventions.

5.6.1. Interpretation of the co-design process in terms of the theoretical promise

In general, we find that the complexity coastal system was addressed in this co-design process in terms of social-cultural and bio-geophysical systems and their interrelations but the level of detail of the designed solutions was lower than initially expected. In this section, the activity is interpreted by exploring how the results align with the theoretical promise of co-design. So, the activities are interpreted in terms of knowledge sharing, and the state of understanding bio-geophysical and actor network complexity (see Table theoretical promise in Chapter 3) and the summarizing Table 5-8 on the next pages.

Natural system complexity

In co-design workshop 1, presentations on the bio-geophysical system were given to the local participants. This served as extra input for the co-design activity, and to build shared system understanding of the natural system, its complexity and the uncertainties in it. However, the main focus on the bio-geophysical system complexity in this co-design process was in workshop 2. Owing to the expert knowledge of the participants in this second workshop, geomorphological and hydrodynamic influences on the coastal system were considered in detail. This is shown by the packages of measures that were co-designed in the second workshop. These mainly focused on, and proposed innovations in, the physical system, with additional consideration for potential adaptations in law and regulations.

Social system complexity

The preferences of local experts regarding future visions are indicative of local perspectives and underlying values. Additionally, local experts make their systems view and values explicit (in workshop 1 and 3), and the value dilemmas (intermediate analysis) provided additional handles to discuss these values.

Actor network complexity was considered appropriately in the designs. The co-design activity especially the designed packages of measures of co-design workshop 2, clearly showed understanding of the complex coastal system. This is illustrated by the co-designed physical solutions that were adapted to fit the policy

Table 5-8 Summary and comparison of the outcomes of activities of the primary case study, in terms of the theoretical promise as presented in Table 2-2 (1a-1e, 2a-2f, 3a-3d). Theoretical promise that was addressed is indicated in brackets bold text. Theoretical promise that was not addressed is indicated is indicated in brackets in italics.

#	Case study elements that contributed to shared understanding of natural system complexity	Case study elements that contributed to shared understanding of social system complexity	Case study elements that improved knowledge sharing
Co-design workshop 1	• In co-design workshop 1, presentations on the bio-geophysical system were given to the participants, including the interrelations between the geophysical and ecological subsystems (**1a**). • The participants were asked to co-design utopic and dystopic visions on long temporal scales (30 to 50 years, even as far as 100 years). Recent insights on geomorphological and hydrodynamic influences on the coastal system were presented in the workshop considered by the participants in designing their visions (**1b**). • Experts gave input on geomorphological and hydrodynamic influences, on state-of-the-art research outcomes regarding geomorphology, and on the coastal system's ability to maintain the coastal ecosystem (**1c**). • The role of environmental changes and storm events were discussed during these expert presentation (**1d** and **1e**). • This was reflected in the workshop outcomes, as visions showed consideration of deeply uncertain factors such as climate change and sea level rise, and their potential impacts on Texel (**1d** and **1e**).	• In co-design workshop 1, the activity of building shared system understanding among participants led to rich discussions, appreciation of different viewpoints and appreciation for the collaborative activity itself (**2a**). • Several times, the discussions moved from the bio-geophysical system knowledge to the character of Texel (**2b** and **2c**). • The main focus points for the designs were how any proposed changes would affect the socio-economic subsystems (**2c**). • The co-design visions were presented as directions for long-term solutions for the island, and physical changes in several visions were linked to the policy and institutional contexts (**2e**), or required institutional designs (**2f**).	• Participants explicitly appreciated the co-learning and the expert presentation(**3a** and **3c**). • The spatial bounds of the designed future visions matched the living environment of the participants well (**3d**). • Focus points for the designs were how any proposed changes would affect the socio-economic subsystems (**3b**). In other words, changes in and the effects on the living environment of the participants were considered. The focus on future utopian and dystopian visions • Promoted thinking and designing beyond purely coastal management strategies towards shared (desired, undesired and realistic) futures (**3d**).
Co-design workshop 2	• The representation and the level of detail for the natural system varied across the subsystems (**1a**). • The designed packages of measures considered the system in a wide temporal horizon (30 to 50 years), for which the geomorphological influences on the natural system SW Texel are uncertain (**1b**), • Focusing projections of sediment erosion on the sandy shore and on the quality and dynamics in the ecosystem, with attention for the quality of habitats in the bio-geophysical system (**1c**). • Additionally, there was explicit consideration of the uncertainty of climatological and environmental influences on Texel (**1d** and **1e**).	• Several proposed innovations in this workshop 2 linked to the policy context and the socio-economic system elements, and demanded institutional change (**2c, 2e and 2f**) between different actors (**2b**). • Knowledge of (non-) involved actors and stakeholders was represented in part by the designed future visions that served as input, including the value dilemmas enriched later discussions among professionals about intervention strategy alternatives (**2a and 2b**), but local participants were not present in the room (*2b*). • The actor network complexity was mentioned several times in the designs (**2c**).	• In co-design workshop 2, interdisciplinary groups of experts were tasked with designing feasible packages of measures (**3a** and **3c**). • The designed outcomes of workshop 2 considered the system in a wide temporal horizon (30 to 50 years) and reflected consideration of long time horizons and appropriate spatial horizons (**3d**). Participating experts for example stated that "the challenge is not the technology, because physical solutions are already here" (**3b**). • Knowledge input from the local participants came only in the form of the co-design from workshop 1, and from the results of the intermediate analysis. There was no additional input from them during the workshop (*3c*).

#	Case study elements that contributed to shared understanding of natural system complexity	Case study elements that contributed to shared understanding of social system complexity	Case study elements that improved knowledge sharing
Co-design workshop 3	• Co-design workshop 3 recapped and reinforced the knowledge on the natural system complexity of the previous workshops (**1a-1e**).	• Co-design workshop 3 continued the conversation about actors' values, perspectives and dilemmas. From these conversations and design validation followed an early consideration of solutions that demanded process and institutional design (e.g., a different approach to 'fair' treatment of beach pavilions) (**2d**). • Discussion of how these solutions could be linking to the ongoing policy discussions and decision-making processes on the island (**2e**). • Institutions and actors that were constraining the solutions space were discussed and addressed (**2f**).	• In terms of improved knowledge sharing, co-design workshop 3 proved to be successful in identifying interactions and coordination issues when designing solutions that have institutional, process and physical aspects (**3b**). • Compatible time and spatial horizons were used and validated (**3d**). Scientific knowledge was recapped, but there was no formal new input on the abiotic and biotic aspects of the coastal system (*3a*), and only local participants attended (*3d*).
Co-design SW Texel (entire process)	• The design of co-design workshop 1 facilitated knowledge exchange on the bio-geophysical system, the were given to the local participants, which served as to build shared system understanding of the entire system, including the natural subsystem, external factors, and its complexity (**1a, 1d**). The ability of the geophysical system's ability to maintain the diversity and quality of habitats characteristic of the ecosystem was discussed as well, albeit more in depth in workshop 2 (**1c).** • The main focus on the bio-geophysical system complexity in this co-design process was in workshop 2. Due to the expert knowledge of the participants in this second workshop, geomorphological and hydrodynamic influences on the coastal system were considered in detail (**1a, 1b and 1c**). • This is shown by the packages of measures that were co-designed in the second workshop. These mainly focused on, and proposed innovations in, the physical system, considering environmental changes and uncertainties (**1d and 1e**), with additional consideration for potential adaptations in law and regulations. • Workshop 3 recaps and wraps back on natural system knowledge, and was a true integrative step in building shared understanding of the bio-geophysical dynamics.	• The preferences of local experts regarding future visions are indicative of their perspectives and underlying values. These were made explicit in workshop 1 and 3, and the value dilemmas (intermediate analysis) provided additional handles to discuss and interpret these values (**2a** and **2b**). • The built shared understanding of the Texel character, and dominating values and value dilemmas (**3b**) • Actor network complexity was considered appropriately in the designs. The outcomes of the co-design activity especially the designed packages of measures of co-design workshop 2, showed understanding of the complex coastal system (**2c and 2d**). • This is illustrated by the co-designed physical solutions that were adapted to fit the policy and social context (**2d** and **2e**). • An additional example of the benefit of a wider design space were the solutions may lie in changing municipal zoning rules to enable changing nourishment strategies (**2e** and **2f**).	• The entire co-design process stimulated participants' basic systems thinking knowledge and skills and promoted thinking beyond each participants' expertise, thus enhancing knowledge sharing on the interfaces of knowledge sources (**3a, 3b and 3c**). • In the first co-design workshop participants built a shared system understanding, where the conversation moved from the bio-geophysical system knowledge, to the Texel character in a wider systems perspective (**3b**). • The set-up of the process with subsequent workshops allowed for knowledge sharing between local experts and disciplinary experts, as specialist experts (scientists and policy actors) are given the task to provide system and discipline knowledge in the first and second workshops (**3c**). • Moreover, the local experts shared their own contextualized knowledge and lived experience on the coastal system of SW Texel between each other. Among other things, the choice for co-design future visions encouraged thinking in long term solutions and designing beyond purely coastal management strategies (**3d**).

and social context (e.g. the co-designs from group 3). An additional example of the benefit of a wider design space were the solutions may lie in changing municipal zoning rules, instead of changing nourishment strategies.

Responses from local experts, the participants who live and/or work on the island of Texel, were overall positive. In fact, respondents considered the co-design process to be valuable and informative. Local experts would unanimously recommend others to participate in similar processes, which is perhaps an indication that the case study did not contribute much to stakeholder fatigue.

Knowledge sharing

Knowledge sharing was a key element in all three workshops. The set-up of workshop 1 allowed for knowledge sharing between local experts and disciplinary experts, as specialist experts (scientists and policy actors) are given the task to provide system and discipline knowledge in the first and second workshops. Moreover, the local experts shared their own contextualized knowledge and lived experience on the coastal system of southwestern Texel between each other. In workshop 2, the knowledge sharing had an interdisciplinary character, and happened for instance through discussion and advising among the participating experts. The validations that happened in co-design workshop 3 offered the (local) participants the opportunity to provide feedback on the previous rounds.

The entire co-design process stimulated participants' basic systems thinking knowledge and skills and promoted thinking beyond each participants' expertise, thus enhancing knowledge sharing on the interfaces of knowledge sources. The first co-design workshop promoted thinking and designing beyond purely coastal management strategies towards shared (desired, undesired and realistic) futures. Here, participants built a shared system understanding, where the conversation moved from the bio-geophysical system knowledge, to the Texel character in a wider systems perspective. Local experts appreciated the knowledge input they received from disciplinary experts, as well as the enthusiastic, friendly and collaborative atmosphere that was created in the workshop. The co-design process as a whole provided insight in the opportunities offered by changing institutions for potential solutions.

5.6.2. Reflection on the design choices and expectations of the co-design process

The application of the designed co-design process allowed for learning on the choices we made in its design. Table 4-2 summarized the choices we made in designing the co-design process. In this section, we reflect on those choices and how they worked to meet our expectations of the co-design process (see also Section 4.4.).

In co-design workshop 1, we saw that the local experts were willing and able to design future visions for southwestern Texel. The local experts learned about new disciplinary insights and expert perspectives of the coastal systems, and were able to include the information on the bio-geophysical and social aspects in the designed visions. Knowledge exchange occurred also through the advisory role of attending disciplinary experts. The future visions were no feasible designs of coastal solutions.

Instead, the future visions were expressions of desired, undesired and realistic futures for the island over long time horizons. The local experts voted according to their assumed role of a key stakeholder group.

The intermediate analysis allowed for investigation of the values and issues that underpinned the voting behavior of co-design workshop 1. Through stakeholder coalitions and clustering of issues, the analysis enabled us to identify three value dilemmas. Although calculation of the Pareto optimum front seems to be a suitable method for shaping the value space to simplify the spectrum of promising design options, unfortunately, communication of the method to participants proved to be challenging in the later workshops. However, the value analysis suggests that there is indeed a shared, broad value space. Different expressions of the value dimensions are manifest in the various designs about the future of Texel.

In co-design workshop 2, we hoped for feasible packages of measures as on iterations n the earlier designed future visions. We conclude from the quality of the designed solutions that the workshop goals and set-up may have been slightly too ambitious. This can be explained as follows. First, the disciplinary experts did not have enough time to gather information. Second, the disciplinary experts were uncomfortable to look at something else than solutions (e.g., values, problems), especially if these were beyond their own expertise. Third, there may have not been enough time to work out the final designs. Fortunately, the co-design activity can be slightly adapted to account for these issues in a next instance of such a workshop. However, the interdisciplinary collaboration included building shared system understanding, and knowledge exchange between experts from different disciplines occurred often during the workshops.

We observe that the iterative nature of the co-design process in its entirety - in which findings in earlier workshops were used as input in the next - allows for adaptivity and ongoing learning. We hypothesize this is unlikely to have been accomplished by through isolated workshops. We also note the importance of adapting the methods throughout the co-design process to account for ongoing learning and changes.

We supplemented the design principles that were found in the theory with a principle on the importance of iterative reflection (P14). The design principle P14 stresses the importance of adapting the design of the co-design process to account for ongoing learning. Thus, this fourteenth design principle addresses the meta-level of design, and is supported by findings in the empirical research, most notable through the primary case study.

We add to the discussion on the unforeseen circumstances that influenced the design of co-design workshop 3 in the previous section. The changes in the group compositions of attending participants solved the expected issues regarding power dynamics. Instead, the approach was changed to have the local experts reviewing the expert designs in detail. Above all, the ability of the organizers to adapt the design and redirect focus of the third co-design workshop to fit the overall purpose of the research, proved to be essential for the usefulness of this part of the results. It is

Table 5-9 Reflection on the choices for designing the co-design process for southwestern Texel.

	Associated design choices for the co-design process (see also 4.4)	**Remarks on design choice after application of the co-design process**
P1	Key component of entire co-design process	Local knowledge and values were sufficiently included in the entire co-design process. However, co-design workshop 2 could have been improved by inviting a 'local expert representative' with an advisory role.
	Key component of co-design workshop 1 and intermediate analysis.	
	Utopian and dystopian futures were co-designed, encouraging participants to envision over 50-100 year time horizons.	
P2	Separation of the local experts and disciplinary experts, and giving them different roles in each of the co-design workshops, including advisory roles ('loketfunctie')	Disciplinary expertise proved to be useful and appreciated, especially in co-design workshop 1.
P3	Key component of entire co-design process, e.g., through the 6-step process in workshop 1, by interdisciplinary teams in workshop 2, and through feedback in workshop 3.	Knowledge sharing between local experts and disciplinary experts, as well as amongst them, was highly successful.
	Plenary sharing of latest scientific insights on the bio-geomorphological system in workshop 1 and 2.	The presentations on different (natural) system aspects were appreciated.
P4	Power re-distribution by starting the process with the local experts	Resulted in local experts feeling appreciated, and opened up the design space and grounds for discussion of a wide range of coastal solutions in later stages.
	Validation of designed solutions in co-design workshop 3	Local experts were able to do a validity check, and to correct designs that misinterpreted their statements.
	Name participants local experts to underline their direct knowledge of the system	This was appreciated. No indication of significance.
	Separation of the local experts and disciplinary experts, and giving them different roles in each of the co-design workshops.	Even with this separation, co-designing participants were still from very different backgrounds. The separation into different workshops offered spaces where people were able to comfortably co-design. This choice has implications for the level of transdisciplinary knowledge sharing during the co-design process.
P5	The co-designs were to be physically realistic, but not constrained to current situation, so as to avoid current stakeholder interests or policy processes playing a dominant role.	Indeed, the freedom offered for the co-designs helped in limiting the influence of ongoing political and policy issues on the island. Especially in co-design workshop 1, no such issues occurred.
	Contextual analysis (ex-ante) on the social system, including the actor network.	The 'ex ante' analyses allowed for the design of the co-design process specific to the southwestern Texel context.
	Contextual analysis (ex-ante) on natural system	
	The location of workshop 1 and 3 on the island was specified to the area near Paal 9.	The choice for the location defined the relevant context.
P6	Co-design workshop 1 and 2 focus on building a systems view that encompasses the socio-economical, natural and governance contexts.	The outcomes of co-design workshop 1 and 2 showed considerations of systemic complexity.
	Focus of the case study was relocated to the area near Paal 9, as there was a more visible and more urgent problem of erosion (as opposed to the Hors)	Relocation of the scope helped in gaining the interests of the local experts through their personal involvement in and familiarity with the area.

Table 5-9 (continued)

	Associated design choices for the co-design process (see also 4.4)	Remarks on design choice after application of the co-design process
P7	Experimental setting parallel to ongoing decision-making process, clearly and explicitly communicated to participants.	No additional remarks.
	Loose coupling of outcomes of stakeholder engagement process and decision-making process	This allowed for freedom in the experimental setting, which was useful for research purposes.
P8	Following TU Delft's Human Ethics Committee standards.	This appeared to gain trust with local expert participants.
	Explicit communication that participants can leave the process and workshop at any time.	
P9	Participant selection considerations included selecting unusual suspects, pre-workshop phone interviews and getting a diverse group of participants using actor network analysis	An additional benefit of this choice was that participants were familiar with the organizers, even before the workshop started.
P10	Community stakeholders are invited to join at the idea generation phase.	The early involvement of local experts helped to let the local experts feel appreciated.
P11	Co-design as a means to achieve a high level of stakeholder engagement.	The influence of the local experts in starting the co-design process allowed for a wide design space and creative outcomes.
P12	Focus in co-design workshops 1 on identifying key factors of interest for Texel and the local experts.	In co-design workshop 1, the step 'why do we care' provided a broad starting point for designing, and a shared understanding of the natural and social aspects of the coastal system of Texel.
P13	Transparent communication on scientific research undertaken objectives.	Scientific and research objectives were clearly and repeatedly communicated to the participants. However, its effects were not significant. Perhaps this is more relevant to the researchers, designers and organizers of the co-design activity.

this adaptivity to account for ongoing learning (see also Baum et al., 2006) that was essential in the usefulness of the outcomes of the co-design process for the primary case study.

5.6.3. Reflection on design principles for co-design

To investigate the observations made in this primary case study on southwestern Texel in a structured way, this section discusses the application of the design principles, differentiating between the three separate co-design workshops, as well the co-design process as a whole. Table 5-10 reflects on whether these design choices were enabling or limiting the co-design process. Below, we discuss some surprising elements.

In conclusion, all design principles are applied and characterized as 'enabling' in the primary case study on southwestern Texel (entire process). This is a logical consequence of the set-up of this research: we specifically set to design the co-design process by applying the design principles, and to this case study context (P5).

Table 5-10 Characterization of the implementation (Y = applied, N = not applied, 0 = no data) of design principles and their impacts in each of the co-design workshop and the overall case study on southwestern Texel (limiting, neutral, enabling, no data).

Principles for designing collaborative, design-oriented activities aimed at innovative solutions for coastal systems		Co-design workshop 1		Co-design workshop 2		Co-design workshop 3		Co-design southwestern Texel (entire process)	
		Applied?	Characterization of effect on outcome	Applied?	Characterization of effect on outcome	Applied?	Characterization of effect on outcome	Applied?	Characterization of effect on outcome
P1	Include local knowledge and local values	Y	Enabling	Y	Neutral	Y	Enabling	Y	Enabling*
P2	Include scientific knowledge	Y	Enabling	Y	Enabling	Y	Neutral	Y	Enabling*
P3	Facilitate knowledge sharing	Y	Enabling	Y	Limiting	Y	Enabling	Y	Enabling*
P4	Give local community and experts equal voices and standing	Y	Enabling	Y	Enabling	Y	Enabling	Y	Enabling
P5	Account for contextual specificity and systemic complexity	Y	Enabling	Y	Enabling	Y	Enabling	Y	Enabling
P6	Appropriate scope	Y	Enabling	Y	Neutral	Y	Enabling	Y	Enabling*
P7	Aim for transparency of relation with policy process	Y	Enabling	Y	Enabling	Y	Enabling	Y	Enabling
P8	Aim for transparent research	Y	Enabling	Y	Neutral	Y	Enabling	Y	Enabling*
P9	Appropriate participant selection	Y	Enabling	Y	Enabling	N	Enabling	Y*	Enabling
P10	Appropriate moment of citizen involvement	Y	Enabling	Y	Neutral	Y	Enabling	Y	Enabling*
P11	Strive for a creative level of engagement practice	Y	Enabling	Y	Limiting	Y	Enabling	Y	Enabling*
P12	Strive for collaborative learning and building shared system understanding	Y	Enabling	Y	Enabling	Y	Neutral	Y	Enabling
P13	Avoid mismatch rationale and goals.	Y	Unknown	Y	Unknown	Y	Unknown	Y	Unknown

Facilitation of knowledge sharing (P3) was a key component of the entire co-design process. This partly happened through inclusion of local knowledge, local values (P1) and scientific knowledge (P2). The table shows that there is room for improvement to include local knowledge in co-design workshop 2, and scientific knowledge in co-design workshop 3. Especially the choice to have a local expert representing the local issues and stakeholder perspectives would have facilitated knowledge sharing in workshop 2 even more – this is why this cell is marked as 'limited'.

However, separating the local experts and disciplinary experts and giving them different roles in each of the co-design workshops worked well in terms of power redistribution (P4). Indeed, the process was designed so that participants (specifically the local experts) could speak up freely. For instance, we ensured every participant being heard, by the roles they were given in the workshops. This is substantiated by feedback in surveys and during the workshop. However, one participant mentioned that during the open discussions, participating men had the tendency to interrupt their fellow participants: mainly the women, but also the other men. This issue was not on our radar before. As such, a lesson here, is that avoiding domination of the discussion by certain (groups of) individuals should always be high on the agenda when design such collaborative design processes, whether that be through differences in education level, language abilities, gender disparity, cultural differences et cetera.

The trust of participants in the 'neutral' organization of the workshop (i.e., not affiliated with policy makers or other actors with interests) was a contributing element in the success of the workshop, as it contributed in an open dialogue between different participant groups. Additionally, trust in the procedure and the neutrality of the research and of the researchers was emphasized by explicit communication on ethics issues and research transparency (P8).

Participant selection (P9) considerations included selecting unusual suspects, pre-workshop phone interviews and getting a diverse group of participants using actor network analysis. The participants were appropriately selected. We avoided including key decision makers to ensure an open co-design process. We also note that the participants attending in co-design workshop 3 were different than originally planned, as indicated by the 'N' in Table 6-8.

In that sense, the degrees of freedom that come with a high level engagement (P10) and creative practice (P11) of the participants can be limiting in terms of outcomes, as such approaches are time-intensive. The depth of the information from co-design workshop 1, combined with the task to co-design packages of measures, allowed for less time to get to actual designing. However, this can also be viewed as a resource issue, as experts are expensive when they work in professional capacity. Additionally, even before the actual designing, discussions enhanced shared understanding of the context in relation to the governance, bio-geophysical and actor network aspects of the coastal system. As such, this still allowed knowledge sharing between the participants and the organization of the co-design process.

We find it difficult to interpret the effects of P13, i.e., whether the alignment of rationale and the goals were limiting or enabling. It is clear to the organizers of the process that transparency of the organization on the goals and limitations of the study led to trust and appreciation of the participants, especially in the co-design workshop 1, and also in co-design workshop 2. However, this is also embedded with design principles P8 and P9. Additionally, we observed variety within the organization team on rationale: one researcher had a more activist stance and want to enable the local citizens to change their environment. Another researcher had more science-related goals and aimed to learn from the observation, independent of its effects in the real world. The necessity and the interpretability of design principle P13 remains unclear, which means in this case that it is unclear on when such activities should be evaluated on what elements.

5.6.4. Concluding remarks

In summary, this co-design process specifically developed for southwestern Texel taught us a number of things. First, the co-design process allowed for finding a solution space for a complex system with different problem perceptions and long-term values of local people. Second, while the breadth of the complex coastal system was addressed in terms of social-cultural and bio-geophysical complexity, the design solutions were perhaps lacking in detail. Therefore, this co-design process was helpful in the earlier design stages (idea generation, defining design criteria, and conceptual designs), but did not get to the later iterations of a design process (preliminary designed alternatives, programs of requirements, final designs). Third, the outcomes that followed directly from the co-design activity, were the effects occurring more in the actor network, as opposed to the designs themselves directly affecting the bio-geophysical system. For instance, we observed that local people were equipped to better engage with the authorities better and to build coalitions amongst themselves. Fourth, an issue that merits consideration is how the design principles were applied in the organization and design of the primary case study. The developed and applied co-design method in Chapters 4 and 5 was tailor-made to southwestern Texel context, but can potentially set the course for future co-design efforts, specifically in the coastal environment.

CHAPTER 6

Comparing collaborative activities in the coastal context

6.1. Introduction

This chapter presents the secondary activities of four collaborative activities in which innovative coastal management solutions were sought through varying methods. Each activity involves a different approach to collaboration and participation. The activities have in common that they aimed to engender collaboration between people from different backgrounds in developing innovative solutions. Some observed activities such as the *Scheldt estuary* (B) attempted to elicit local knowledge. Other activities, such as the calculation norm for sediment nourishment on the Dutch coast (C), consulted experts from similar knowledge domains to elicit expert knowledge. The observers aimed to limit their influence on the activities, process and outcomes. Observations in all activities were made through taking notes, and audio recordings when possible and permitted.

Table 6-1 Overview of secondary activities of collaborative activities in the coastal context

Acitivity	Organized and conducted by	Participants	Intended use of results	Aimed type of results
A. Negril Bay, Jamaica	Researchers in collaboration with, and funded by, Ecoshape	Experts on coastal management with varying expertise	For research purposes, and to explore operational feasibility of exporting Dutch concept, so: corporations	Explore international potential of nourishment innovations
B. Core group meeting Scheldt Estuary	Collaboration between government authorities ('gedeputeerde staten') and project organization	Community stakeholders. Disciplinary experts also had a role.	Advising policy-makers on a specific decision	Develop a shared system understanding of the Scheldt Estuary with all participants to inform policy making
C. Calculation norm for sediment nourishment on the Dutch coast	Researchers Deltares	Coastal experts with varying expertise	Final insights are to be considered for formal coastal policies.	Discover learning status among coastal experts
D. The Slufter	TU Delft researchers in collaboration with the water board.	Local people, local management, and experts on coastal management	For research purposes.	Explore role of participants' system understanding

Each of the secondary activities is first analyzed individually. The final section cross-compares the observations.

6.2. A. Negril Bay, Jamaica.

This activity comprises a workshop for designing innovative solutions for beach erosion of the Negril Bay in Jamaica. The following sections describes the findings for each component of the conceptual framework.

6.2.1. Content controlling input: the problem context

The input to an activity is everything that is provided to the activity. A specific type of input is contextual input. The context in which this work session takes place is described in terms of the bio-geophysical and social context of the Negril Coast in Jamaica.

The problem area of the Negril Bay, Jamaica[1]

The Negril Coast is located at the Western tip of Jamaica, and consists of a strip of hotels, restaurants and resorts, representing a significant component of the tourism sector of the island (est. 20% d.d. 2015). Jamaica earns around 1000M dollar per year in tourism income, and 20%-30% of the tourists go to the Negril area during their stay. Types of tourism include honeymoon-tourism and drug tourism (e.g., marijuana). Tourism development started in the late 1960s and early 1970s, and has increased continuously over the years. Local facilities include both medium to large scale hotels on the Long Bay and smaller-scale hotels and cottages at the West End. Construction of venues occurred rapidly and in a relatively un-coordinated fashion, which has contributed to weak policies and enforcement. There is a small local fishing industry. Social and economic issues in this area include: drug use, visitor harassment, fishing during the closed season, motorbike riding, horseback riding, and coral reef destruction. Approximately 80% of the services are illegal. Additionally, the area is in the Hurricane Belt, with a high frequency of occurrence of hurricanes (e.g., 2001, 2004, 2005, 2007), which has led to increased rates of coastal erosion.

The local inhabitants have a close and active community and a strong connection to their coast. "The local people who live there are hippies, but they understand enough of the world to think commercially as well: commercial hippies (sic.)". They have seen their beach eroding over the last decades.

Proposed measures to combat the beach erosion include a combination of a beach re-nourishment and a breakwater. This combination is very expensive. Beach nourishments cost minimally 35 dollar per cubic meter, which is expensive, probably due to the fact that high-quality sand is needed and harvesting the sand is also

1 Summary of the problem area and its physical setting. Information served as input, and was provided to the participants during the workshop and in workshop documents in June 2015 (i.e. not fact-checked, not up-to-date, and the statements do not reflect the opinion of the author. Where necessary, findings are translated and edited from Dutch.

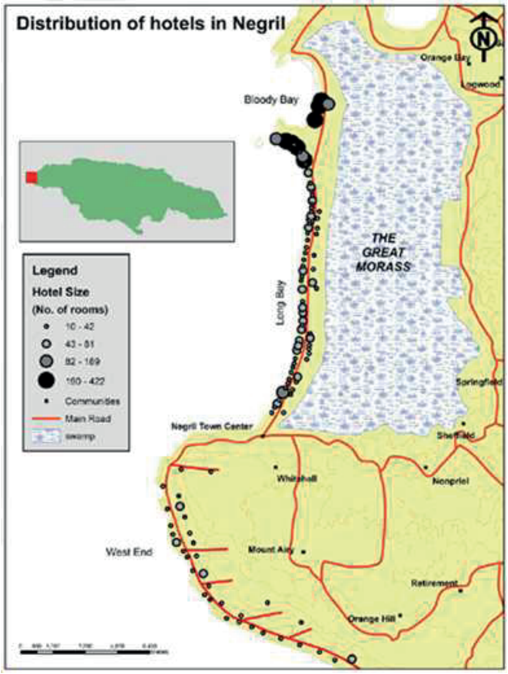


Figure 6-1 Tourist activities at the Negril Bay at the West Coast of Jamaica. Map was provided in the workshop.

problematic. Breakwaters are permanent, safe and economically feasible, but will prevent new sediment accretion. However, sediment nourishments represent a temporary fix, because of frequent hurricanes.

The measure proposed by the Jamaican authorities was to place offshore underwater boulders before the Negril coast, the most economical option (approx. 5.4 million USD). However, the local coastal community actively opposed this plan, owing to the negative impacts on the sensitive coral ecosystem, the effects on tourism, and the incomplete consultation and Environmental Impact Assessment (EIA) procedures, as well as lack of trust in the government. Public outcry in the media put the plan on hold (temporarily, at the time of the workshop). Key stakeholders include hotel owners, inhabitants, and entrepreneurs. Other influential stakeholders are the 'founders' of Negril as a tourist destination. Some of these influential stakeholders have requested advice from EcoShape, a partner in the NatureCoast research program about coastal defense, and hope for an alternative solution to the underground breakwaters.

Additional bio-geophysical information

The Negril beach erosion is substantial, with erosion rates of ~1 meter per year, or ~50000 cubic meter per year. The bay is a shallow and sediment-rich bay, with a slope ranging from 1:50 – 1:100. A coral reef (5-6 meter wide), frequently visited by tourists, is located in deeper water (approximately 2.5 km from the beach). The size of the coral reef has decreased, because fishermen have blown up parts of the reef for fishing purposes. The bed along the outer 2 meter wide reef is a potential source of sand for harvesting. Tidal variation is limited, with spring tides of 0.6 m, and neap tides of 0.2 m. North West storms result in significant wave heights ranging from 5 m with a 5 year return period, to 8 m with a 25 year return period. Sea grass fields stabilize the bay area and trap and retain sand in the system (180 – 5000 m^3 sand). They produce calcium-rich sediments and function to attenuate waves and reduce erosion under normal conditions. Sea grass is removed above -3 m towards the beach for the tourists, more erosion occurs when sea grass is lost. The hotels are built on the sandy barrier that separates the Great Morass from the ocean. The Great Morass is a protected wetland area. The small Negril River flows out to the sea from the south east corner of the morass. Additionally, a small canal was built for drainage.

The project context

NatureCoast, a STW perspective science project that ran from 2013 to 2019, aimed to investigate the potential and feasibility of innovative (Dutch) sediment nourishment techniques internationally. This workshop was undertaken as part of the research project.

6.2.2. Process controlling input: characterization of the workshop design

What is the stated purpose of the activity? A design-oriented work session on finding innovative solutions for beach erosion of the Negril Bay in Jamaica was undertaken on 10 June 2015. The workshop was conducted in Dordrecht, the Netherlands. The working title of the session was 'Benefit-oriented design of Building-with-Nature solutions for Negril'. The workshop aimed to explore the potential for sediment nourishment, comparable to the Sand Engine approach, in this tropical, coastal area. A benefits-oriented lens was offered through a presentation.

Who organizes and facilitates the activity? The workshop was carried out and chaired by researchers from NatureCoast. The content was supplied in the form of presentations by the researchers (Table 6-2). Later, in the design sub-activity, each design group had an assigned facilitator during the design sessions.

Who participates in the activity? Participants included experts with knowledge from a variety of disciplines, e.g., coastal morphology, long-term coastal development, mega-nourishment experts, geomorphologists, ecologists, a hydraulic engineering master student, environmental impact assessment experts, experts on beach nourishments in the Netherlands and coastal engineers. And all were selected through the EcoShape network. Access to the activity was obtained through J. Slinger, a co-applicant in both the NatureCoast project and the CoCoChannel project.

What activities are undertaken? The workshop took one morning. The participants were asked to explore Building with Nature possibilities, to assess which additional information is needed, and to evaluate the work session (Table 6-2). Two sub-activities form the focus of the analysis. First, the introduction about

Table 6-2 Focus and workshop program with sub-activities for the design session for solutions for the Negril Bay, Jamaica

Workshop program		Clarification of sub-activities
9.00-9.30	Coffee	
9.30-12.30	Design session	Introduction about benefit-oriented design *(Content controlling input)*
		Introduction, containing information about the problem area, proposed solutions and information about the physical system *(Content controlling input)*
		Benefits game to introduce benefit-oriented design *(Content controlling input)*
		Actual design session: designing BwN solutions for Negril in two groups *(Focus of this analysis)*
		Feedback by participants in a plenary session (*Outcomes*)
12.30 -13.00	Lunch	

the problem area was in the form of a presentation with room for questions. Then, the design session, which took on a free format in two smaller groups, each with a facilitator.

6.2.3. Activity

Prior to the workshop, we (the observer) stressed our observing role, and that we wouldn't co-design with the others. We chose to observe the design session of one group in detail, while the results from the other group were discussed plenary.

Process of the design session

First, the plenary group lists the following qualities of the Negril coast: safety, fish stock, recreation, water quality, salination problem, freshwater production deficit, and the entertainment caliber of the area. The latter was an idea of one of the participants to encourage tourists to stay longer in the Negril area (currently on average 6.6 days).

Then, co-designing the solutions started. The group was split into two interdisciplinary groups of seven people. The group was assigned a captain tasked with facilitating the design process. The process in the first group went as follows. First, the group started with a discussion about the basis for the designs. This extensive and factual discussion went on between a few of the most vocal participants. At some stages, the group discussion turned into a dialogue between the facilitator and a participant. At a later stage however, the less vocal participants were also included. The other design group took a different approach. First, they brainstormed and designed a few alternative solutions, and only later identified the information that they needed to fulfill the design.

In a plenary feedback round, all participants were asked to contribute their opinions about the process, and to a lesser extent, the quality of the designs.

Substantive content

The content controlling information in paragraph was presented and discussed in the observed group. In the discussion of the observed group, engineers were pushing for solutions, quantitative experts were asking and giving numbers and figures about the system, and social experts discussed the value for the local people and the gaps in understanding. This meant that the discussion progressed slowly. In the final 20 minutes, the observed group tried to design actual solutions, but kept falling back into discussion, e.g., the width of the beach, sea level rise, who will pay for the solutions, what the local stakeholders actually want. The given information was questioned and supplemented during these exchanges.

6.2.4. Outcomes

Observations during the workshop and the plenary feedback serve as data.

Content: designed alternative solutions. Of the two groups, only one group managed to design a solution. This group proposed coral reef development between two reefs (0.5 – 1 meter per year), an artificial reef, and a coastal upgrade fund to compensate future hurricane damage. This fund may also be used for education or reef maintenance. The second group first designed according to key considerations, and then they worked out any missing information. Key considerations included that coral is important, and that vegetation needs water that isn't too saline.

Alternative solutions, as discussed by the entire group, included:

- A pipeline to pump sediment when needed, to supplement the beach width to form a buffer zone, because a 20 meter wide beach is perceived as undesirable by the local community. This was considered a reasonable idea by the group, albeit with certain issues.
- Either only natural nourishment by coral reef, or small-scale nourishments.
- No (more) high-rise buildings (e.g., hotels).
- The breakwaters are possible, but not desired by the hotel owners, because they don't believe in a technical solution. Some in the group consider this a matter of bad communication.
- Managed retreat as opposed to nourishment
- Natural variants of the breakwater, e.g., with vegetation and/or shellfish instead of artificial structures.

Summary of plenary feedback on process and content

Knowledge gaps on substantive content were identified during the plenary feedback. First, both the system analysis and the intended benefits of the solutions are essential, and both are not completely understood at the moment. Second, the question about who will pay for the solution remains unaddressed. Third, stakeholder information is missing, as there are no stakeholders at the table, which makes the validity of the social aspects of the designed solution weaker. However, some social factors have been taken into account in designing, e.g., the choice to calling the solution a 'reef' and not a breakwater is also a social one, as it is expected to get less opposition.

Fourth, stakeholder values and preferences are not known. Finally, other missing information includes the degree of visibility of the beach, length of tourist stays, and preservation of the natural character of the island.

The process that this workshop followed was different from a similar workshop in November 2014 (not observed), but the designed alternative solutions remained similar. Some participants agreed that more analysis and calculations needed to be done. Others suggested earlier inclusion of stakeholders or stakeholder representatives. Some participants noted that it was difficult to design with all the information, and others stressed the importance of showing the effects of designed solutions directly.

6.2.5. Use and effects

As long-term effects are impossible to catch in workshop observations, and are more fully captured in longitudinal studies, the use of the workshop outcomes and the effects of the workshop fell beyond the scope of this research (McEvoy et al., 2019). However, there has been some reported learning on the workshop to be noted. First, learning occurred that the Sand Motor cannot be copied blindly (Luijendijk & van Oudenhoven, 2019). Solutions for coastal erosion problems are site-specific, and a mega-nourishment solution such as the Sand Motor should not be unadulterately applied to other sites around the world. Solutions should consider the societal, governance and environmental context. In many regions, such as in Jamaica, sand is too costly to harvest and sediment nourishments are not necessarily suitable for a coral reef area. As such, the designed solutions for the Negril Coast in Jamaica were substantively sub-par and not suitable for the Negril Coast. Innovations that work in the sandy Dutch coast, such as mega-nourishments, are not appropriate for coral reefs (Luijendijk & van Oudenhoven, 2019).

6.2.6. Interpretation of the activity

As described in the introduction (6.2.1.), the work session was part of an overarching research project. However, the activity is characterized here in isolation of other related activities and in terms of enhancing understanding of the natural and social system, and of improving knowledge sharing. These categories are drawn from the theoretical promise of co-design within the coastal context.

Natural system complexity

The purpose of the co-design work session, involved investigating the utility and feasibility of Dutch coastal nourishment innovations. Accordingly, the designed alternative solutions proposed changes in the bio-geophysical system (e.g., reefs, nourishments). Geomorphological and hydrodynamic influences on the coastal system were especially considered. Interrelations between the geophysical and the ecological subsystems were addressed, most notably the ability of the geophysical system to maintain the diversity and quality of habitats. Environmental impacts were discussed, and the influences of climatological and meteorological events, such as hurricane events, formed an important element in the current problem.

Social system complexity

The context of the workshop, and the background of the organizers and some of the participants led to a setting where participants habitually consider, and were encouraged to consider, solutions that benefited dredging companies. The designed alternative solutions were discussed in terms of whether they would involve dredging activities, or other activities that could be 'sold' in addition to advice and consultancy. This was something that the organizers of the workshop were transparent about. The designed solutions considered the actor-network in the Netherlands, but the actor network in Jamaica was not really considered. As such, the designed alternative solutions did include a social intervention in the form of a coastal upgrade fund, but this was not elaborated. Considerations about the Jamaican actor network were missing. Cited reasons for this were lack of knowledge on money streams and resource availability on the island, and other missing stakeholder information. Content controlling input on knowledge of social values, the social system and actor network was missing. The interrelations between the social, institutional and governance system were discussed but not considered. Solutions that lie in social aspects of the coastal system, included the limiting high-rise buildings in the coastal strip, but no relevant actors involved in such decisions were mentioned.

Knowledge sharing

Engineers, coastal modelers, bio-geomorphologists and social scientists collaboratively designed solutions. However, they did not discuss well together. Typically, engineers pushed for (physical) solutions, coastal modelers and bio-geomorphologists asked for more data and questioned the available data, and some social scientists wanted to know more about the local community and questioned assumptions made about them. All of these stances and concerns are valid, but did not contribute to a fruitful discussion.

Stakeholder perspectives, interests and the values of the local community were underrepresented and under-considered. A proposed solution for this could be to assign someone with an advocacy role to represent the local requirements.

In the group discussions and the design sessions, the quieter, and coincidentally more nuanced people participated less in the discussion. Additionally, one group (the observed one) never designed. More structured facilitation, or work procedures, could nudge participants into moving from the discussion phase to the actual doing phase.

There appeared to be little understanding of the cultural differences between the Netherlands and Jamaica. Jamaica's cultural context was oversimplified and stereotyped. Notions such as (paraphrased) "drug tourism on Jamaica is always unwanted", "the cultural value is limited, as there are limited historical buildings", "they are commercial hippies", were not, or rarely challenged during this session.

Figure 6-2 Map of Scheldt estuary. The border between the Netherlands and Belgium is between Bath and Liefkenshoek (Vlaams-Nederlandse Scheldecommissie, 2019)

In conclusion, whereas learning on the bio-geophysical system occurred, there was limited learning on interactions and interfaces between the social, governance, and environmental systems. Specifically, the effects on the local community of the designed physical solutions to prevent beach erosion were not considered, nor were the implications for local governance in developing policy for such solutions. The most learning occurred on the process aspects of the workshop, and on the limitations of specific Dutch sediment nourishment strategies in different environmental and social contexts.

6

6.3. B. Core group meeting Long-Term Perspective Scheldt-estuary

6.3.1. Content controlling input: the problem context.

The Scheldt (Dutch: *Scheldt*) estuary lies on the border of the Netherlands and Belgium, and is one of the largest fully tidal estuaries of the North Sea. The estuary supports important habitats, and consists of the ‘Westerschelde’ (English: Wester Scheldt), and the ‘Zeeschelde’, which is part of the Scheldt river.

Natural system complexity

The Scheldt tidal movement has changed over the last century. Human interventions in the system, such as dikes, empoldering, dredging and hard structures, have made the estuary narrower, the channels deeper and the estuary shorter. As such, the high tides have become higher. The Scheldt estuary has a full salinity gradient and sand flats that contribute to richness in habitats and biodiversity. The changes in tidal movement, the limited influx from the rivers, and the dumping of dredged sediments may contribute to more muddy waters, which affects the primary production and has other effects in the ecosystem. Vegetation and animals in the Scheldt estuary use the water and soil as their living environment or habitat. The Scheldt estuary is rich in habitat quantity and variety. The low dynamic intertidal areas are especially important, as birds and fish feed on the soil biota. The current trends are that the intertidal mudflats are becoming more dynamic in the Zeeschelde, which has a negative effect on the biodiversity. The Westerschelde is more stable.

Social system complexity

The area has an economic function, with four major ports on the estuary, including Antwerp in Belgium. Typical for the area is that stakeholders generally mistrust the governments, especially when is about coastal management, owing to large and far-reaching coastal management projects and interventions in the past. In particular, the act of moving flood defenses land inwards as to make more room for water, is a sensitive topic in the Dutch province of Zeeland. This sensitivity was one of the reasons to undertake this stakeholder engagement process.

In a T2015 report (Barneveld et al., 2018), an evaluation of the system functioning based on bio-geophysical elements: safety from flooding, navigability and natural/ecosystem, including water quality and flora and fauna in the Wester Scheldt area, was supplied.

The project context

The Flemish-Dutch Scheldt committee (*Vlaams-Nederlandse Scheldecommissie, VNSC),* commissioned the Long-Term Perspective Nature Scheldt estuary (LTP-N) in 2016. They wanted a wide consensus over the factual basis for a new long-term perspective of the Scheldt-estuary. The objective of this stakeholder engagement process is to formulate advice for the VNSC, focusing on two questions: how robust and resilience is the nature of the Scheldt-estuary, considering climate change and the use of the estuary? And if not, what should the VNSC do about it? The information gathered in the process will be used as a basis for policy development on this theme. Part of the joint-fact finding process included: collaboratively formulating a plan of approach and the rules of the game in 2017, a series of interviews, five plenary workshops, a series of core group meetings between the workshops in which the next plenary workshops were prepared, and the sharing of all preliminary products and results with the stakeholders. Experts fed information about the estuary into the activity, through reports of evaluations on the safety, navigability and nature. These evaluations are summarized in Barneveld et al. (2018).

The analyzed workshop is one of the core group meetings, discussing the results of the third plenary workshop. The third plenary workshop debated and made improvements to the theme document Habitats and Flora and Fauna. The other themes are Hydrodynamics and Morphology, and Water Quality.

A wide range of stakeholders were invited to the process, and 30 stakeholders accepted the invitations, among which representatives and members from nature organizations, port authorities, agriculture, citizen initiatives, recreation societies and the governments from Flanders and the Netherlands who are not directly involved in the VNSC. Additionally, seven experts from Flemish and Dutch research institutes were asked to share their knowledge on the themes. Additionally, eighteen employees of the governmental organizations involved in the VNSC joined.

At the time of the observed workshop, some adaptations to the process design were made. The project deadline was extended by three months until spring 2019. Additionally, the process intended to collaboratively design policy advice, but other tasks with more priority were more time consuming than expected.

6.3.2. Process controlling input: characterization of the workshop design

What is the stated purpose of the activity? The workshop (core group meeting) is an experiment, in the sense that it hasn't been done before and "we try it out with each other". In this workshop the focus on joint fact-finding. The stakeholders were required to assess the quality of the system analysis, the product of a previous workshop, and to ground their normative valuations on facts, i.e., is it going well or badly and why? The workshop took place on the 24th of October 2018 in Bergen op Zoom, the Netherlands.

Who organizes and facilitates the activity? The combination of the envisaged products is a system analysis. The entire process is supported by the deputed states ('gedeputeerde staten'), by the financing project organization and the text writer. The facilitator is an experienced process manager. Additionally, a disciplinary expert on the Scheldt and a person responsible for project documentation were present.

Who participates in the activity? The participants are local people living around the Wester Scheldt, most of them associated with organizations described in the project context. The minimum required number of participants is eight. A previous date for the workshop was cancelled, because not enough people could attend. Today, there were ten stakeholder participants present from the provincial authorities, nature organizations, recreational organizations, and port authorities, from Belgium and the Netherlands.

What activities are undertaken? The workshop took a full day. After a plenary introduction and a recap, there were four thematic sessions. For each theme, the current state of affairs, and our valuation of that state was discussed. The themes are pioneer vegetation, soil biology, low-dynamic littoral, and birds (*kustbroeders*), and possibly seasonal migratory birds.

6.3.3. Activity

Process of the design session

The entire day was in plenary with facilitated discussion. The participants, and the project organizers, sat in a circle. The facilitator stood in front of a whiteboard. The group of stakeholders decided together what they value as important within their system. Participants used expert knowledge from the disciplinary experts, either presented or from reports and other documents to substantiate their claims. Certain participants were less vocal than others during the discussion, and others seemed unmotivated to join the detailed discussions, which did not resonate with their problem perception. Underlying the discussions are the fundamental values of the participants. For example, some measured the success of the ecosystem in terms of the success or presence of certain *key species* (e.g., cockles). Others prefer to discuss the balance within the ecosystem and view a balanced ecosystem as healthy, but didn't mention this explicitly. Again another participant did not like to say "we want a healthy Scheldt", as that would imply that the current state of the Scheldt is unhealthy.

During the workshop, there were discussions about the substantive content, discussions about the process, and discussions about the value of the system. Causal relations are discussed as well. One participant monitored the internal and external consistency, for instance the coherence between the values of the various factors. Additionally, fundamental differences regarding the importance of the legal framework exist in the group: on the one hand it is seen as guiding and not to be ignored, on the other hand, the legal framework is considered changeable by some participants.

Substantive content

A paper with the following text was hung on the whiteboard: "the system analysis focuses on the way in which biotic and abiotic components in the estuary develop. The analysis should make clear whether the nature is sufficiently robust and resilient to retain characteristic estuarine values against a background of climate change and human use" (Translated from Dutch). The discussed topics were: low-dynamic littoral subsystem, soil biology, pioneer vegetation, abiotic factors, and birds. Discussions were about identification of the weak links in the system, and what interventions on which particular system elements would be the most effective. The focus of this system analysis was the ecosystem. Humans were not considered in the system analysis.

6.3.4. Outcomes

Content

The participants collectively were tasked with deciding whether they find the known numbers about the system factor, acceptable or not. This is called the valuation. For instance, do they find the number (un)desirable, (un)concerning, good, bad, neutral, positive, negative, (un-) certain? Coming to such a valuation together was sometimes problematic and led to complicated discussions. Dilemma's included, good for whom, because good for the pioneer vegetation means bad for the entire ecosystem, good for the exotic species means bad for the soil biology, some bird species are not doing well, but that is also the case in the entire Netherlands, and sublittoral area cannot be compared with a pristine area, because there are no pristine areas. The organizers made the distinction between assessing the current state and the current trend, which solved some of these discussion points.

Summary of comments by organizers after the activity

The biggest concern was the time consuming nature of the fact-finding discussion, which involved identification, valuation and assessment of the system elements. Preparing statements in the form of sentences by the organizers were considered as a possibility to speed up the discussions, and organizers have to keep an eye on particular stakeholders who would not continue participating within the current setting.

6.3.5. Use and effects

The results of this workshops served as input in an ongoing process. The results of the final process are published in Vlaams-Nederlandse Scheldecommissie (2019), with a description of the bio-geophysical system, trends and their (un)desirability.

6.3.6. Interpretation of activity

Natural system complexity

The key focus of this workshop, and of the entire process, was the bio-geophysical system. The interrelations between the geophysical and ecological systems were well elicited, but the focus was on the separate subsystems. Causal relations between species, in terms of a food network, were considered in detail. For example, increasing soil biota has a positive effect on mollusks and that in turn will attract birds. The environmental impacts on the estuary were only considered in terms of robustness and resilience of the Scheldt estuary.

Social system complexity

The workshop, and the entire process were highly participatory, and relevant stakeholders were present. The values of stakeholders were revealed when the group was asked to assess the current figures. However, the focus did not lie on the underlying values of the participants, nor on the values held by the broader population living around the Scheldt area. Solutions involving the social side of the system weren't considered, as they weren't a focus of this project. However, some discussion about linking the findings and the assessment to the policy context occurred during the session.

Knowledge sharing

Local knowledge was included in this process. Additionally, where the participants may not have been experts at the beginning of this stakeholder engagement process, by the time of the observed workshop they had a very high level of detailed knowledge about the Scheldt-estuary system, including vast knowledge about bio-geophysical subsystems. Constraining legal frameworks were discussed. The sharing of scientific knowledge occurred through the disciplinary experts who were also present in the workshop. Again, the knowledge and perspectives of the involved and non-involved actors were not discussed explicitly.

6.4. C. Calculation norm for sediment nourishment on the Dutch coast

Analyzed data includes observations, audio recordings and post-workshop surveys. The focus of the analysis is on one of the break-out session within the overall workshop.

6.4.1. Content controlling input: the problem context

The project context

The workshop (Dutch: 'Invuloefening Rekenregel Suppletievolume') took place on 3 October 2018, at Deltares, Delft, the Netherlands. The workshop serves to explore the assumptions underlying the calculation rule for nourishment volume norms along the Dutch coast, based on the memo dated 13 September 2018 called 'Rekenregel supplietievolume' by Lodder.

Table 6-3 Detailed workshop program Deltares calculation norm and focus of this analysis

09.30 – 10.00	Coffee				
10.00 – 11.00	Plenary presentations				
	Opening (Department Head Deltares)				
	Calculation rule and current status / embedding (Quirijn Lodder)				
	Structure of policy advice and role of calculation rule (researcher / advisor Deltares)				
	Design and approach long-term research in Kustgenese 2 (researcher / advisor Deltares)				
	Explanation program and breakouts (project manager Deltares)				
11.00 – 11.15	Short break				
11.15 – 12.15	Breakout 1.				
	Group:	Wadden 1	Wadden 2	Deeper foreshore 1	Deeper foreshore 2
12.15 – 12.45	Plenary feedback breakout 1				
12.45 – 13.30	Lunch break				
13.30 – 14.30	Breakout 2.				
	Group:	Subsidence in coastal foundation	Wester Scheldt	Landward boundary foreshore coastal foundation	State boundaries (Belgium, Germany) (this analysis)
14.30 – 15.00	Plenary feedback breakout 2 (this analysis)				
15.00 – 15.15	Short break				
15.15 – 16.00	Conclusions				

The memo summarizes and reflects upon the conceptual foundations for the average annual sediment nourishment volume for the Dutch coast over the last few years. The working of the coastal system has been structurally investigated over the last few decades. Based on the insights from these investigations, the memo presents an adapted calculation rule (Dutch: 'rekenregel') for determining the annual nourishment volume needed. The memo also makes a preliminary estimation of the annual average nourishment volume based on the new calculation norm.

6.4.2. Process controlling input: characterization of the workshop design

What is the stated purpose of the activity? The purpose of this workshop day is to explore the assumptions underlying the calculation rule. This represents an attempt

Table 6-4 Self-reported disciplinary backgrounds and further specializations of the participants of the workshop.

#	Disciplinary background participant	Further substantive specialization participant
1	Physics and governance	Estuarine morphology
2	Morphology	Research management and consultancy
3	Coastal morphology	Tidal inlets, nourishments
4	Coastal engineering	operational auditor
5	Civil engineering	Water security
6	Physical geography / geomorphology	Waddenzee, policy, politics, management
7	Physical geography	Deep foreshore, morphology
8	Physical geography	Subsidence, long-term coastal development
9	Coastal morphology	Long-term coastal development
10	Physical geography	Moving geology, archeology
11	Civil Engineering	Coastal Engineering -> Tidal inlet morphodynamics
12	Civil Engineering	Coastal morphology
13	Coastal morphology	Sediment transport and morphology
14	Coastal morphology	Bank dynamics
15	Coastal morphology	-
16	Coastal morphology	-
17	Civil Engineering	Coastal morphology
18	Water quality, integration	Modeling, policy analysis
19	Civil Engineering	Financial sensitivity
20	Quaternary geology-Physical geography	Coast line care technical advisor, advisor nourishments, future nourishment volumes, foundations framework Kustgenese

to understand the extent of the design space for potential sediment nourisment solutions. Coastal experts are required to discuss the approach and to come to a preliminary policy advice for different elements of the calculation rule.

Who organizes and facilitates the activity? The larger workshop is organized by Deltares. Experts facilitate parallel breakout sessions, and feedback is discussed in plenary with the help of a facilitator from Deltares.

Who participates in the activity? 24 – 30 participants attended the workshop, not all of whom remained for the full day. Participants were experts with high-level disciplinary knowledge and expertise about coastal processes, modeling and management. In their self-reported disciplinary backgrounds (Table 6-4), a significant portion of them (10/20) reported having expertise on (coastal) morphology. This is less homogeneous than it appears, because participants each have their own field of expertise within coastal morphology, which was required because of the specialized nature of the workshop. In the break-out sessions, 5-9 participants were present.

What activities are undertaken? After a plenary session, the experts were subdivided into four groups to discuss issues related to the calculation of nourishment demands and nourishment volumes for different coastal subsystems in the Netherlands. The focus of this analysis is on one of the breakout sessions: State boundaries (Belgium, Germany).

6.4.3. Activity

Content of the breakout session. The focus of the breakout session was introduced. In the Dutch coastal management strategy, 'sediment volume demand' is an important variable, meaning that the amount of sediment that leaves the Dutch coastal system over time, influences the necessary nourishment volume needed to maintain the sandy coast. Under the current calculation norms, it is assumed that the net sediment transport over the state boundaries is zero. This means that it is assumed that the volume of sediment entering the system at the Belgian border near the Westerschelde equals the volume of sediment leaving the Dutch coastal system at the German border at the Eems Dollard. In this breakout session the experts were required to explore this by expert estimations of the sediment flow near the two boundaries.

Aids included a white-board, pen and paper maps of the relevant areas.

Process of the breakout session. The facilitator, an expert on long-term coastal development, introduced the assumptions and broke the problem area down into smaller sections. Then, for each section, the group of participants estimate directional sediment transport, the sum of which formed the overall estimate. The direction of the overall flux alone was considered sufficient, and actual figures associated with the arrow would be even better. The facilitator drew estimates out on the white-board and on the maps, asked pointed questions and defined the unknown variables.

6.4.4. Outcomes

The participants were tasked with reconsidering the assumption in the calculation norm of no net flux across the Dutch borders. However, nobody actually believed the assumption. In this session, four main sediment influxes were identified. The resulting estimate for the Belgian border came down to 1M cubic meter sediment influx per annum.

Estimating the fluxes over the German border was more difficult to define. The depth of the Groninger Wad does not change much, so sediment transport from the Groninger Wad to the Eems must exist. Many studies about the Eems exist. The final estimation assumed the sediment transport over the German border compared to the sediment transport along the line of the neap tide ('wantij') of Schiermonnikoog, i.e., 2 to 3 M cubic meter sediment per annum.

The conclusion of the session was that we cannot assume that the net sediment transport for the Dutch coast equals zero. The sediment outflux is estimated to be 2 to 3 times as much as the sediment influx. Reflecting on this exercise, it cannot be stressed enough that this is an estimation, but it is a telling estimation and the numbers are significant (i.e., 10% of the total sediment nourishment volume per annum).

6.4.5. Use and effects

The workshop involved (very) preliminary research results and annual volumes. During the day, the organizers and participants drew on their deep tacit knowledge and tried to use preliminary research results to estimate preliminary policy-relevant annual volumes. Any further information about these numbers, their use and effects are under embargo, and we are therefore prohibited from sharing the use and effects further in this analysis. This does not affect the interpretation of the activity significantly.

6.4.6. Interpretation of activity

Natural system complexity

The focus of the breakout session and the larger workshop was on the geomorphological system of the Dutch coast and its dynamics. External influences, such as meteorological and climatological impacts on the coastal system were discussed as external factors: the coastal system needs to be robust to floods and sea level rise, and the discussion was about attaining the required safety norms in the long term. These formed a boundary condition for the discussions. The biotic system complexity was not considered.

Social system complexity

A significant number of participants are researchers or policy advisors, meaning that they had deep knowledge about coastal decision making processes and management. The activity did not necessarily go into additional actor complexity, and the purpose of the activity was not related to actor network complexity either.

Knowledge sharing

The workshop functioned as an interdisciplinary activity, where high-level professionals with deep knowledge and expertise about a subject (coastal management) came together. Because of the detailed level of knowledge, the day had an integrative character. However, the group of participants would be considered quite homogeneous from an outside perspective. As mentioned in the process controlling variables, a significant number of the participants (10/20) reported their expertise as (coastal) morphology.

The workshop, and the input from the memo, underline the technology-focused and information-rich tradition of Dutch coastal management.

6.5. D. The Slufter, Texel, the Netherlands

6.5.1. Content controlling input

The problem area of the Slufter, the Netherlands

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

One of the reasons for this study (as reported in: (D'Hont, 2014; D'Hont et al., 2014; Slinger et al., 2020) was the idea of reducing management interventions at the mouth of the estuary and letting nature take its course in the Slufter in the future. Triggered by insights from simulations with new storm wave models (Rooijen & van Thiel de Vries, 2013), a research goal was to create new system knowledge on stakeholders' perceptions and estuary morphodynamics in a collaborative setting in which current practices in managing the inlet of the Slufter were under discussion. To achieve this goal, outcomes from a system dynamics study (see also D'Hont et al., 2014) were used to open up the discussion and learning on behavior of the estuary system. An causal model based on Slinger (2017) was used to describe the constraining effect of the sill height and mouth cross-section on the in- and outflow of water through the estuary mouth. As water flows to the sea, sediment is eroded from the mouth channel and the sill height is lowered. As a result, the mouth cross-section increases and enhances the flow through the mouth. This forms a reinforcing erosion feedback loop. However, when sediment laden seawater flows into the estuary with the tide, the sediment is deposited in the mouth channel. As a result, the sill height increases, and the associated mouth cross-section decreases, which in turn constrains the flow through the mouth. This forms a balancing feedback loop. Whether the mouth shallows or deepens over time is determined by the balance between the erosion and deposition in the mouth (D'Hont, 2014).

Figure 6-3 The Slufter on the Northwestern coast of Texel, The Netherlands (picture: Flying Focus)

Additionally, the social functions and perspectives on the Slufter were discussed in the workshop, as the Slufter also is a tourist attraction, drawing nature lovers, particularly bird watchers, and hikers and cyclists to the island of Texel, and generating economic value to medium and small business enterprises. There are more slufters and slufter-like nature areas in the Netherlands, but the Slufter is a natural salt-marsh and the most stable one in the Netherlands (Pedroli & Hoekstra, 1992). As protected nature area, the Slufter forms part of several ecological networks established and safeguarded by national and European legislation. Other relevant stakeholders include governmental authorities, environmental organizations, nature managers and the citizens of the island. However, the value of such an estuary is perceived differently by the different actors (Costanza et al., 1997; Farber et al., 2002).

Results of a stakeholder analysis of interview results were presented in the workshop. Identified use functions of interviewees, who were all people with direct knowledge of the Slufter, included "(i) a component of the primary flood defense, (ii) a nature reserve with vegetation and birds, (iii) a location of sediment flows in the North Sea, (iv) recreational area, (v) part of a recreational route, (vi) a tourist attraction, (vii) a bird habitat for foraging, resting and breeding, and (viii) part of a migration route for birds"(D'Hont et al., 2014, p. 11). The results of the stakeholder analysis were presented in a way consistent with systems thinking. For instance, the diversity of spatial scale perspectives on the Slufter was discussed, as some viewed the Slufter as a stand-alone, small scale nature reserve, while others considered it as a nested ecosystem in a greater island-wide Wadden-Sea whole, or even as an essential link in a global bird migration network. On a smaller scale, stakeholder perspectives revealed concerns regarding bird habitats or dune front areas susceptible to erosion.

Although there was no need for policy change from a flood defense perspective, there was room to allow for more natural dynamics in the area, resulting in a regimen that is more in line with societal and ecological values.

6

The level of detail of the supplied information was considered appropriate for the participants with real-world understanding of the estuary. Specialized, disciplinary or abstracted conceptual knowledge was limited.

The project context

The workshop was part of a larger research focused on deepening system understanding with stakeholders in the particular case of the Slufter (Figure 6-4). The Slufter and similar small estuary systems are under-researched in the Netherlands and worldwide (Slinger, 2017). By gathering a wide range of knowledge from different sources and sharing new knowledge in a collaborative workshop setting,

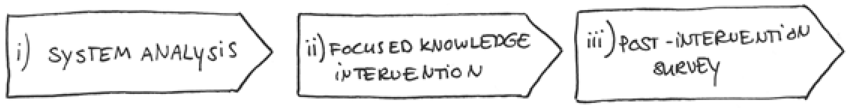


Figure 6-4 The project context in three stages. The analyzed activity of collaborative activity D was the focused knowledge intervention (ii).

Table 6-5. List of participants for the Slufter activity D. (D'Hont, 2014).

Number	Background	Affiliation	Participant's perspective
1	Nature manager Texel, vegetation and monitoring	Nature manager	Ecology
2	Ecologist within district water board, implementation of Natura 2000 regulation, bird watcher	HHNK	Ecology and policy
3	Researcher, ecologist	Deltares	Ecology
4	Researcher, ecologist	Deltares	Ecology
5	Researcher on morphodynamics in the Slufter	Deltares	Abiotics
6	Student	VU	Abiotics
7	Student	VU	Biotics
8	Researcher on flood defense policy	HHNK	Water safety and policy
9	Manager regarding sandy coasts of North Holland	HHNK	Water safety and policy
10	Formerly operational flood defense management on Texel	HHNK	Water safety
11	Inhabitant Texel, regular tourist guide in nature reserves on Texel	National Park Dunes of Texel	Ecology
12	Researcher on morphodynamics	Deltares	Abiotics
13	Operational management flood defense management of Texel Member of crisis management team Texel	HHNK	Water safety
14	Bird watcher and nature photographer	Bird watchers club	Ecology (birds and landscape)

the researchers aimed to deepen understanding of both the social and the ecological aspects of the small estuary system, with the end objective of including other values besides flood defense in the policy making process.

The research approach yielded a conceptualization of the Slufter in two ways, by a) gaining knowledge on stakeholders' values and positions through interviews, and by b) building a simulation model to analyze the intrinsic abiotic dynamics of the Slufter under normal weather conditions. Results from the interviews served as input for the workshop, and included the wide range of stakeholders' perception on the Slufter as a system, on policies regarding the Slufter and on the qualities of the area. The results on abiotic behavior patterns and stakeholders perspectives served as input to the workshop.

6.5.2. Process controlling input: characterization of the workshop design

What is the stated purpose of the activity? The activity on the Slufter provided an opportunity to explore the role of system understanding in support of integrated management of a small estuary The primary objective of this workshop was to feed insights on system complexity to the stakeholders, while a secondary objective was to investigate the degree to which participants reconsidered their preferred policies and the importance of Slufter characteristics.

Who organizes and facilitates the activity? Facilitation of the workshop day was done by an employee of *Hoogheemraadschap Hollands Noorderkwartier.* Design and organization of the workshop was done by researchers from the Faculty of Technology, Policy and Management from Delft University of Technology, among which the author. An additional person was assigned the task of keeping time and intervening in discussions when necessary.

Who participates in the activity? Invited participants included coastal modeling specialists, as well as citizens from the island with individually different perspectives and ready knowledge of the Slufter. The fourteen attending participants are shown in

Table 6-6 Program activity D the Slufter and focus of this analysis.

12.00 h Entry
12.15 h Welcome
12.30 h Workshop: Over het karakteristieke gedrag van de Slufter, het gebruik van en de waardering voor dit natuurgebied *(this analysis)*
14.00 h Coffee break
14.30 h Conclusion workshop
14.45 h Presentation: New insights in morphology and possible ecological developments of the Slufter (Deltares)
15.45 h Closure

Table 6-5.The participants group was a mixture of researchers familiar with modeling techniques and local actors from the island, all with individually different viewpoints and substantial, ready, real-world knowledge of the Slufter.

What activities are undertaken? The entire workshop took one afternoon, from 12.00 to 15.00 hr. This included a pre-workshop questionnaire, then two presentations including discussions, followed by a voting session and a post-workshop questionnaire. The first presentation contained insights from the system dynamics model study about the characteristic behavior of Slufter-type systems. The second presentation provided a synthesis of the findings regarding social functions and the perceived system behavior derived from the individual interviews. An ex ante voting form was used to assess the individual participant's system understanding and values. The workshop closed with an evaluation round, where participants were encouraged to share their opinions on the day.

6.5.3. Activity

A synthesized understanding from the system analysis, including the simulation model outcomes and stakeholder analysis was presented to the participants in a workshop setting in the form of two presentations. The participants group was a mixture of researchers familiar with coastal modeling and citizens from the island, all with individually different viewpoints and substantial, ready, real-world knowledge of the Slufter.

The level of detail of the supplied information was chosen to be appropriate for the participants with real-world understanding of the estuary, but with limited specialized, disciplinary or abstracted conceptual knowledge.

One of the discussions followed directly from the presentation of abiotic estuary dynamics and behavior. Participants were encouraged to consider the situation of normal weather conditions and ordinary tidal dynamics, as opposed to other meetings and workshops on the Slufter that commonly emphasized flood defense and consequently the situation of exceptional storm weather conditions. The aim in this regard was to increase dynamic system understanding of the participants by discussing known dynamic behavior and system boundaries that related to the individual real-world experiences of the participants. As expected, the discussion quickly diverted from water safety, and participants were able to communicate regarding the potential consequences of dynamic estuary behavior on vegetation and birds, based on the information supplied.

Another discussion was on stakeholder perceptions and values. For instance, participants repeatedly came back to discussing the importance of wild nature versus human interference. The participants agreed that finding a balance between human interventions and wild nature remains difficult.

6.5.4. Outcomes

The aim for activity D was to learn from the role of system understanding in support of coastal management issues. Outcomes are reported in detail in (D'Hont, 2014; D'Hont et al., 2014; Slinger et al., 2020). Here, we note the following key outcomes.

First, participants did communicate their individual values and exchanged some knowledge on the system, thereby creating some increased common knowledge. The study revealed that participants' opinions change, albeit not radically. For instance, the quality of the Slufter as a bird habitat or migration route was more valued after the event than before the event.

Second, the activity design was naive in that it did not take power relations and habitual interactions amongst stakeholders into account. An imbalance between participants (policy makers vs experts vs local stakeholders) skewed the discussion, and may have influenced the learning from the activity. Accordingly, the activity could have been designed to be more inclusive. Similarly, the (perceived) non-neutral facilitation may have hindered open discussions as well.

Third, the richest discussions addressed system dynamics ('how the system works'), as opposed to defining the system 'what the system is'. Similarly, discussion of stakeholder values, system understanding, and the ecosystem services that natural systems deliver, can create a space in which participants can share knowledge.

Fourth, we saw an example where local knowledge supplemented the findings from the simulation models. A discussion was triggered by the supplied information on the dynamic behavior of estuaries. The system dynamics model that was part of the 'content controlling input' identified that freshwater inflow must be significant in order for the mouth to keep opening when closed. This was discussed as being a potential reason for the historical difficulty in reclaiming the Slufter area. Local people identified that freshwater inflow in the system was significant, especially after rainfall and in specific seasons, and could estimate the inflow volume. Others, including some disciplinary experts, disagreed and would rather not classify the Slufter as an estuary with significant freshwater inflow. At the time, freshwater inflow was not measured in the Slufter.

Finally, the activity was partially successful in the sense that participants experienced it as positive: it met substantive goals and there were fruitful discussions.

6.5.5. Use and effects

The research on this workshop was documented in a Master's thesis 'Does deepening understanding of social-ecological systems make sense?' (D'Hont, 2014), which concludes with advice on management and monitoring strategies. The system dynamics modeling part and some of the knowledge intervention was additionally published as D'Hont et al. (2014). Additionally, a presentation was given at the Hoogheemraadschap Hollands Noorderkwartier, the regional water board, because the master thesis was the product of an internship with them. However, the research did not have any direct policy implications for decision-making on management of the Slufter mouth.

6.5.6. Interpretation of activity

Natural system complexity

A discussion was triggered by the supplied information on the dynamic behavior of estuaries. The system dynamics model that was part of the *content controlling input* identified that freshwater inflow must be significant in order for the mouth to keep opening when closed, and could possibly be a reason for the historical difficulty in reclaiming the area. Local people identified that freshwater inflow in the system was significant, especially after rainfall and in specific seasons, and could estimate the inflow volume. In that discussion, some disciplinary experts disagreed, and would rather not classify the Slufter as an estuary. At the time, freshwater inflow was not measured. This example indicates that local knowledge can be used to supplement simulation models and system understanding, as well as to provide a better interpretation of hydrological influences in the system.

Additionally, the character of the nature reserve's ability to maintain the diversity of habitat characteristics was discussed extensively. Particularly the local people, but also the experts, were mostly concerned with the Slufter's ecological value.

External influences such as climatological impacts were not discussed explicitly.

Social system complexity

The difference and the interrelation between the social institutional and governance systems were addressed and explored by sharing knowledge and seeing whether perspectives changed. The participants were given input on the social values and preferences that exist on the island. The workshop also confirmed that local people had knowledge of and access to relevant authorities in case of a problem in the nature reserve or elsewhere on the island. The (perceived) non-neutral facilitation may have hindered open discussions as well.

Knowledge sharing

In this workshop, it was not the discussion of 'how the system is', but the discussion of 'how the system works' that facilitated knowledge exchange in the session. The workshop facilitated acknowledging these different scale perspectives amongst the participants, which in turn facilitated learning. Also, local and indigenous knowledge of the area played an important role in the workshop setting, and in the accompanying research (see Wolff et al., 2019). An attempt was made to link these solutions and system understanding to the valuation of policy options. Unfortunately, the set-up of the group, which was mixed, resulted in a discussion where the more knowledgeable experts were more vocal in the discussion, hindering full knowledge exchange.

6.6. Comparison of the results

After observing each of the collaborative activities, this final section compares them. This section explores the link between practice and the theoretical promise of these methods to address key elements, namely: to enhance understanding of natural system complexity, to enhance understanding of social system complexity, including actors' values and perspectives, and to improve knowledge sharing. Later, we reflect on whether or to what extent the design principles were implemented in the collaborative activities (Table 6-7).

6.6.1. Characterization of similarities and differences

To characterize the collaborative activities A through D, we return to the understanding of co-design that was built in Chapter 2. All the secondary activities used workshop settings and shared an approach where the workshop activities were complemented by preparatory analyses carried out by research teams, e.g., interviews, scientific studies, or reporting. All collaborative activities involved group deliberations in workshop settings as the primary 'platform'. The activities are similar in that they are aimed at collaboration between people coming from different disciplinary backgrounds. Additionally, they searched for innovative coastal solutions. The collaborative activities were different in regard to who participated, and in their purpose and underlying rationale, as elaborated below.

Similarly, comparing the level of participation and collaboration reveals differences between the activities. An essential difference between the four secondary activities (A-D) and the primary case study lies in the degree of inclusion of the public in the activity and, similarly, whether local knowledge was provided to the activity. Collaborative activities B, D, and the primary case study had clear participatory components, and facilitated dialogues between local stakeholders and experts. Activity C did not include members of the public, which matched with its purpose as it was not intended to include local knowledge. Instead, the purpose of that workshop was to share knowledge between people with specific expertise related to management of morphology of the Dutch coast. However, activity A aimed to design an innovative solution for the coast of the Negril Bay, Jamaica. Limited information about the local system, however, prohibited functional or appropriate design outcomes, emphasizing the necessity of including such knowledge at some point, preferably early, in a design process.

In conclusion, the secondary activities differ in many ways, and are analyzed on a different level from the primary case study. So, to achieve generalizations and learning, we compare and analyze further at the activity level.

6.6.2. Comparison in terms of the theoretical promise of co-design

From the analysis of theory in Chapter 2, we have constructed a list of effects that collaborative activities aiming at innovative solutions in the coastal context could potentially (and ideally) fulfill. Table 6-7 shows a summary and comparison of the outcomes of the secondary activities in terms of this theoretical promise, giving insight in whether this theoretical promise materializes into a *practical* promise, based on the (limited and fragmented) observations made in this Chapter.

The differences in scope and theme of the observed workshops (A-D) limits comparison of the workshops' effects in terms of the theoretical promise. For instance, in activity C on sediment nourishment, by design did not much to consider actor network complexity much. Instead, the workshop focused on the abiotic elements and relations within the bio-geophysical system only, ignoring social elements that were out of scope. However, relevant knowledge of decision making processes was present in the room.

Table 6-7 Summary and comparison of the outcomes of co-design activities, in terms of the theoretical promise as presented in Table 2-2 (1a-1e, 2a-2f, 3a-3d). The theoretical promise indicated and addressed in brackets in bold text. Theoretical promise that was not addressed is indicated in brackets in italics.

	Elements that enhanced shared understanding of natural system complexity	Elements that enhanced shared understanding of social system complexity	Elements that improved knowledge sharing
A. Negril Bay, Jamaica	• Interrelations between the geophysical and the ecological subsystems were addressed (**1a**), most notably the ability of the geophysical system to maintain and the diversity and quality of habitats (**1c**). • Environmental impacts were discussed (**1d**), and climatological and meteorological events, such as hurricane events, were key aspects of the problem (**1e**).	• Very limited understanding of social system complexity. Content controlling input was missing on knowledge of social values, social system, and the actor network, so there was limited representation non-involved stakeholders or indigenous knowledge of the coastal system (*2a and 2b*). • The interrelations between the social, institutional and governance system were not explicitly considered (*2c*). There was no consideration of solutions in the institutional, policy and social domains (*2d, 2e, 2f*).	• The focus of this activity lay on the sharing of technical/engineering knowledge, and the abiotic and biotic aspects of the coastal system (**3a**). • All participants are experts on disciplines related to coastal engineering, ecology and management. Local stakeholder perspectives and values of the local community were underrepresented and under-considered, which resulted in limited knowledge sharing on these aspects of the coastal system (*3c*).
B. Core group meeting Long-Term Perspective Scheldt-estuary	• The key focus of this activity was the bio-geophysical and ecological subsystems (**1a**). • Causal relations between the existence of species, in terms of a food network, were considered in detail (**1c**). • Changes in the Scheldt estuary due to climatological and environmental impacts were explicit focus of the activity and process that the workshop was embedded in (**1d and 1e**).	• Relevant actors were present. Stakeholders were selected to represent a wide range of local interests (**2a and 2b**). • Values of actors were revealed when the group was asked to assess the current figures (**2a**). • However, the focus did not lay on the underlying values of the participants, and not on the other values that were present in the population living around the Scheldt area (**2a** and **2b**). • The outcomes of the process (of which the workshop was part of) linked findings to the policy context (**2e**). • Issues and solutions were discussed in terms of the natural system, and not the social or institutions (*2d* and *2f*). • Constraining legal frameworks were discussed (**2f**), but seen as external to the process the workshop was part of (*2c*).	• Local knowledge was present in this process (**2a, 2b**). • Additionally, where the participants may not have been experts at the beginning of this stakeholder engagement process, by the time of the observed activity they had a very high level of detailed knowledge about the Scheldt-estuary system, including vast knowledge about bio-geophysical subsystems. • This contributed to knowledge exchange between participants across backgrounds (**3c**). • Sharing of scientific knowledge occurred through the experts that were also present in the activity, which was a deliberate design choice of the activity (**3a**).

	Elements that enhanced shared understanding of natural system complexity	Elements that enhanced shared understanding of social system complexity	Elements that improved knowledge sharing
C. Calculation norm for sediment nourishment on the Dutch coast	• Focus on the coastal geophysical, system and geomorphological influences in the context of flood safety in the Dutch coast (**1b**). Environmental impacts and other external influences on the coastal system were considered with respect to the geophysical system (**1d and 1e**). • The interrelations with ecosystems, habitats and biodiversity were out of scope for this activity (*1a and 1c*).	• A significant part of the group of participants are researchers or policy advisors, meaning that their they had deep knowledge about the decision making bodies and processes, as well as awareness of the relevance of their findings to future decision making **(2e and 2f)**. • The activity did not necessarily go into additional actor complexity, as the purpose of the activity was not related to actor network complexity (*2a, 2b, 2c and 2d*).	• Coastal experts of several disciplines within the field of physical geography, coastal morphology, civil engineering, water quality and public administration theory were present and participated (**3a and 3c**). • Limited acknowledgement of social or ecological subsystems. • Because of the detailed level of knowledge, the day had an integrative character. However, the group of participants would be considered quite homogeneous from an outside perspective (*3c*). • By workshop design, solutions were considered over a time horizon that corresponded with the problem situation at hand (**3d**).
D. The Slufter, Texel, The Netherlands	• The character of the nature reserve's ability to maintain the diversity of habitat characteristics was discussed extensively (**1c**). Particularly the local participants, but also the experts, were concerned with the Slufter's ecological value, as was the link with the ecosystem (**1a**). The activity delved into the hydrodynamics and geomorphological influences on the Slufter (**1b**). • External influences such as climatological impacts or environmental changes were not explicitly discussed in depth (*1d and 1e*).	• The difference and the interrelation between the social institutional and governance systems were addressed and explored by sharing knowledge and perspectives amongst participants and exploring whether changes occurred (**2a and 2b**). • The interrelations between the social, institutional and governance system were not explicitly considered (*2c*). • Moreover, links with the policy context were discussed, but limitedly (*2e*), • nor were the opportunities offered by institutional and governance systems for potential solutions (*2f*). However, governance bodies were not completely ignored, as participants' access to authorities was considered key in the functioning of management of the area (**2f**).	• In this activity, it was not the discussion of 'how the system is', but the discussion of 'how the system works' that facilitated knowledge exchange, including knowledge of abiotic and biotic system aspects, governance of the water boards, and stakeholder preferences (**3a and 3b**). • Sharing of scientific knowledge on hydrodynamic and geomorphological aspects of the Slufter was one of the key objectives of the activity (**3a**). • Expert knowledge and local knowledge were shared amongst participants (**3c**).

In terms of understanding the natural system complexity, each secondary activity had its strengths and weaknesses. Collaborative activities B and D intended and succeeded in building a shared system understanding of the bio-geophysical system. Activity B did this through analysis of links between the occurrence of characteristic species and the abiotic conditions they require in the ecosystem of the Scheldt. It had, as such, a narrow focus on the bio-geophysical system characteristics. Activity D also considered the abiotic and biotic aspects, and attempted to extend the system understanding of the bio-geophysical system to its respective social contexts, e.g., ecosystem services and actor preferences and values.

In terms of understanding the social system complexity, the collaborative activities have in common that where people meet, new actor relations can develop. Unfortunately it was beyond the scope of this thesis to track these effects for the secondary activities and this was not measured. Activity B on the Scheldt estuary could have had effects in the actor network, as people participating in the activity and in the broader process have met and collaborated together on building a shared system understanding. Additionally, activity D on the Slufter did have demonstrable effects in the actor network, as the organizers of that activity were first-time collaborators, and this collaboration that has since been extended to the primary case study. The primary case study on southwestern Texel did have as indirect, and secondary effect, that discussions between local actors and policy makers on the erosion problem became more structured and later touched on innovations in municipal zoning regulations as opposed to shore nourishment strategies alone, a possible indirect effect of the broader solution space (extending beyond the bio-geophysical system) and the coalition-building opportunities offered by the activities.

In terms of knowledge sharing effects, which here means whether the undertaking each of the activities had any effects relating to knowledge, such as the diffusion and dissemination of knowledge or changes in the way of working for (groups of) actors. For activity A, the unsuccessful outcomes of the design activity had the notable effect of inducing 'learning-by-failure'. Lessons on the necessity of acquiring knowledge of the local social and ecological system contexts were drawn by the organizers (Luijendijk & van Oudenhoven, 2019). This lesson is common in transdisciplinary research, where highly contextualized problem situations prohibit extending methods and solutions to other sites unadulteratedly (Bergmann et al., 2012). For activity B, effects could lie more in insights in how to use stakeholder perspectives and local knowledge in improving the valuation of system characteristics, and on how to apply this in more universal problem situations. For collaborative activities C and D, no further effects on knowledge sharing were noted.

6.6.3. Reflection on principles for co-design

An issue that merits consideration is whether the design principles were applied in the organization and design of the collaborative activities. To generalize results beyond the secondary activities, this section discusses the patterns and key points observed regarding the design, organization and application of such activities.

It appears that, in some of the observed activities, collaboration is expected to just happen when getting people together in the same room, as it is 'design' or 'collaborative design'. In Table 6-8, each of the activities are characterized in terms of whether the (eventual) application of a principle was applied, and whether it enabled, or limited the outcome of the activity, or whether it had no effects or was not intended to have any effects (neutral). We observe a few regularities and surprises. Most notably, the design and application of the core group meeting on the Scheldt Estuary (B) has shown application of all the design principles, (except for P13, which is discussed below). That they applied all the design principles is unsurprising in the sense that the organizers, process developers and facilitators had experiences and skill in similar citizen-engagement processes. To illustrate the design principle on transparency with the policy process (P8), the relation of the observed meeting specifically, and the wider process more generally, with the policy process was communicated clearly and repeatedly. Additionally, the limitations of the meeting were made explicit, by reiterating that the aim was to advise decision makers, and no promises were made to actually change decisions. Moreover, the aim for transparent research (P7) was explicitly mentioned when the observer was introduced, and the participants were encouraged to speak up if they would prefer to have no observers in the room, which was in line with the openness of the entire process.

In the activity of the Slufter (D), the level of citizen engagement and creative practice (P11) was limiting in a way that we did not expect. The activity was designed to give the experts and local community equal standing (P4), but this did not work out as planned in the workshop application and thus limited knowledge sharing in the activity. The group dynamics, resulting from the differences in knowledge and standing between the participants, limited the knowledge sharing and open discussions. While the design principle on careful participant selection (P9) was applied, in hindsight the workshops should have been done differently to allow for more open group discussions and transdisciplinary collaboration.

Additionally, for the workshop on the calculation norm (activity C), the purpose was not related to using local knowledge (P1 and P2) and facilitating knowledge sharing along two epistemic paths. Instead, the purpose was to facilitate knowledge sharing among experts. This is considered to be enabling, because local knowledge was not needed, and because the presence of public actors would have hindered the free and open discussion of preliminary results that were under embargo. Similarly, this explains the lack of implementation of the design principles in activity C. From this, we conclude that the design principles are only relevant if they fit with the purpose of designing using local knowledge and values.

As discussed before, the workshop on the Negril Bay, Jamaica (activity A) proved to be a sub-optimal in its design. The most notable element missing in the design of this workshop was the information on the socio-economic system, on local citizens and their preferences. Unsurprisingly, this defect in the design shows up in the analysis of a number of design variables (P1, P4, P5, and P10). If we leave that issue out, we see that other design principles were applied and can be interpreted as enabling. For instance, supporting creative practices (P11) and knowledge sharing (P3) both

Table 6-8 Characterization of the implementation (y = applied, n = not applied, 0 = no data) of design principles and their impacts in each of the activities (limiting, neutral, enabling, no data).

Principles for designing collaborative, design-oriented activities aimed at innovative solutions for coastal systems		A. Negril Bay, Jamaica		B. Core group meeting Scheldt-estuary		C. Calculation norm for sediment nourishment on the Dutch coast		D. The Slufter, Texel, The Netherlands	
		Applied?	Characterization of effect on outcome	Applied?	Characterization of effect on outcome	Applied?	Characterization of effect on outcome	Applied?	Characterization of effect on outcome
P1	Appreciation for local knowledge and local values	N	Limiting	Y	Enabling	N	Neutral	Y	Enabling
P2	Appreciation for scientific knowledge	Y	Neutral	Y	Enabling	Y	Enabling	Y	Enabling
P3	Facilitate knowledge sharing	Y	Enabling	Y	Enabling	Y	Enabling	Y	Enabling
P4	Give local community and experts equal voices and standing	N	Limiting	Y	Enabling	N	Neutral	N	Limiting
P5	Account for contextual specificity and systemic complexity	N	Limiting	Y	Enabling	N	Neutral	Y	Enabling
P6	Appropriate scope	N	Limiting	Y	Enabling	Y	Enabling	Y	Enabling
P7	Aim for transparency of relation with policy process	N	Unknown	Y	Enabling	Y	Enabling	Y	Enabling
P8	Aim for transparent research	Y	Neutral	Y	Enabling	Y	Enabling	Y	Enabling
P9	Appropriate participant selection	Y	Enabling	Y	Enabling	Y	Enabling	Y	Limiting
P10	Appropriate moment of citizen involvement	N	Unknown	Y	Enabling	0	Neutral	0	Neutral
P11	Strive for a creative level of engagement practice	Y	Enabling	Y	Enabling	Y	Enabling	Y	Limiting
P12	Strive for collaborative learning and building shared system understanding	N	Limiting	Y	Enabling	Y	Enabling	Y	Enabling
P13	Avoid mismatch rationale and goals.	Y	Unknown	Y	Unknown	Y	Unknown	0	Neutral

enabled the collaborative design practice in the workshop, especially within one workshop group. Additionally, expert knowledge was core to the workshop and the participants were from a wide range of backgrounds.

However, whether the underlying rationale and the purpose are matched (P13), is often difficult to establish in hindsight, as underlying rationales are not always known, and if they are known, they are rarely made explicit in documents. Indeed, we sometimes observe a discrepancy between an idealistic rationale and the purpose of the study. For instance, in the activity of the Slufter (D), the researchers had an underlying motivation that stems from the conviction that local policy changes should be made in consultation with the local community *because that is inherently democratic,* but the research project aimed to investigate an operational pragmatic rationale building system understanding. We hypothesize, but cannot confirm through these empirical observations, that this discrepancy exists and may possibly be limiting co-design applications. Further research can give insights on how co-design can work under these different rationales.

CHAPTER 7

Conclusions and reflections

7.1. Synthesis of findings

In this research, we set out to *understand how to design and strengthen co-design activities in a coastal management context*. Coastal system knowledge is in this research emphatically viewed as something in the Dutch coastal context that can help improving supported design solutions, that can be increased, and that can be shared between scientists, experts and (local) stakeholders. In previous chapters, we have explored the link between practice and the theoretical promise of co-design methods to address key elements, namely: to enhance understanding of natural system complexity, to enhance understanding of social system complexity, including actors' values and perspectives, and to improve knowledge sharing. We argue that while the design of the site-specific co-design activities needs to be contextual, the process to be followed in designing and refining such activities is generic. Therefore, we also reflected on whether or to what extent the design principles were implemented in the primary case study and the observed secondary collaborative activities (Table 7-2). In this section, we summarize the findings.

Generally, we have seen that few of the secondary activities addressed the social-ecological system as a whole (e.g., The Slufter D). Some secondary activities focused on the social aspects and some on the environmental system only (e.g., Scheldt estuary B, Negril Bay A), or on the hydro-morphological subsystem only (Calculation norm C). We also note that the observed collaborative activities in the coastal context happen in the early stages of the engineering or coastal management decision making process, and (in our observations) are rarely directly linked to it.

In terms of the presence of (elements of) design and different manifestations of design, the Negril Bay (A) and the primary case study were the most design-oriented, aiming for significant steps in the design process by coming to conceptual designs and/or design criteria (Figure 1-2). However, the limited success of the outcomes of the Negril Bay (A), where ignorance of local perspectives actually led to a low quality of designed outcomes, shows that co-design by interdisciplinary teams is not useful when essential design principles are not observed.

A well-designed co-design process can potentially indeed meet the theoretical promise of co-design. We see this especially in the collaborative activities of the primary case study of south-western Texel, where depth of understanding of different

Table 7-1 Overview of the coastal problems that were the focus of the primary case study and the secondary observations

Activity	Pre-dominant problem focus
Primary case study south-western Texel	Find solution for the erosion hotspot on south-westernTexel (near on Paal 9)
A. Negril Bay, Jamaica	Find solution for coastal erosion at Negril Bay
B. Core group meeting Scheldt Estuary, the Netherlands	Assess and develop a shared system under-standing of the Scheldt Estuary to inform policy making
C. Calculation norm for sediment nourishment on the Dutch coast	Evaluation of sediment erosion and nourishment to inform policies
D. The Slufter, Texel, the Netherlands	Coastal erosion & environmental monitoring of a small estuary and nature reserve

subsystems effectively encouraged design of solutions that encompassed institutions, policies and changes in the bio-geophysical landscape. We summarize the key findings on the design principles for co-design in the coastal context below and in Table 7-2.

A significant number of the design principles relate to knowledge, different types of knowledge, knowledge sharing and integration (P1, P2, P3, and P5). As coastal management can involve large engineering infrastructure projects, coastal management and coastal engineering are well-integrated. Solutions for coasts are drawn from formal knowledge in scientific and practitioner's knowledge bases, in addition to the informal, practical, real-world knowledge from actors and stakeholders who live near the coast. In such contexts, it is unusual that one institution holds all the relevant resources, let alone all the relevant knowledge.

We note that it is difficult to assess the implementation of the design principle P13, to avoid a mismatch between the purpose and the rationale of the activity, as this mismatch is rarely documented and is difficult to observe. There is often a discrepancy between the rationale for choosing participation and the more outcome-driven objectives, such as building better policy decisions or gaining legitimacy. The two activities developed and undertaken by the author, Slufter (D) and southwestern Texel (primary case study), explicitly state their underlying idealistic rationales in their documentation. Both were research-oriented collaborative activities, and their activities were parallel to, and explicitly decoupled from, ongoing decision-making processes.

In terms of rationale, the primary case study on southwestern Texel was initiated through an activist stance and aimed to empower the local citizens to influence their living environments.

The Negril Bay, Jamaica activity (A) had a pragmatic, operational purpose, as this activity had the objective of exporting Dutch knowledge and methods abroad, and the workshop was an exploration of the international potential for nourishment innovations. This is an effect of underlying attitudes of the organizers and some of the participants in secondary activity A, and is in contrast with co-design as we applied it in the primary case study, which aimed for empowerment, inclusivity and democratization. The collaborative activity on the nourishment calculation rule (C) is interpreted as having a pragmatic rationale, as it aimed to underpin nourishment strategies at the operational level, and underlying assumptions were challenged in this activity. The rationale of the collaborative activity of the Scheldt estuary (B) is unclear: while the workshop and the larger process aimed at developing a shared system understanding of the Scheldt estuary with local stakeholders to inform policy making (pragmatic reasoning), the choice for participation happened earlier, and organizers and initiators of the project are likely to have a rationale linked to democratic ideals, equity and empowerment.

Some of the activities have included citizens, stakeholders or other actors in the activity, as a means to facilitate their inclusion in the policy debate in a substantive way. Underlying the participatory policy analysis view are values such as equality, citizen empowerment, and democratization. This research examines collaborative activities to determine whether certain groups of people have been excluded from policy debates. We see that for the observed collaborative activities, the Negril Bay (A) and the calculation norm for sediment nourishment on the Dutch coast (C) have designed the activities in a way that did not include the local community. Only in secondary activity A was this damaging to the outcomes of the workshop. The difference can be explained by the purpose, the context and the specificity of the topic of the workshops.

7.2. Answering the research questions

RQ 1: What is co-design?

As discussed in the literature review of Chapter 3, co-design is a fairly new concept and definitions of the term are still evolving. A broad range of potentially relevant literature is available to understand it better. However, little work has focused solely on co-design processes for the coastal context. Despite some differences, we have distinguished several commonalities.

First, co-design fits with an integrated and participatory management style in water and coastal management, and by extension, fits with a shift towards a bottom-up approach to governance and policy making. Research and practice are looking to include stakeholder values and perceptions in the policy making process. Co-design is one manifestation of this strand of participatory thinking.

Second, co-design aligns with transdisciplinary approaches. The strong contextualization of coastal issues shapes related policy processes. As such, integration occurs at the interface of science and society, but also between scientific disciplines.

Table 7-2 Synthesis and characterization of the implementation (y = applied, N = not applied, 0 = no data) of design principles and their impacts in each of the activities (limiting, neutral, enabling, no data), including the evaluation of the design principles and the differences with the primary case study.

Principles for designing collaborative, design-oriented activities aimed at innovative solutions for coastal systems		A. Negril Bay, Jamaica		B. Core group meeting Scheldt-estuary		C. Calculation norm for sediment nourishment on the Dutch coast		D. The Slufter, Texel, The Netherlands		Primary case study southwestern Texel		Evaluation of design principles
		Applied?	Characterization of effect on outcome	Applied?	Characterization of effect on outcome	Applied?	Characterization of effect on outcome	Applied?	Characterization of effect on outcome	Applied?	Characterization of effect on outcome	
P1	Include local knowledge and local values	N	Limiting	Y	Enabling	N	Neutral	Y	Enabling	Y	Enabling*	Not rejected
P2	Include scientific knowledge	Y	Neutral	Y	Enabling	Y	Enabling	Y	Enabling	Y	Enabling*	Not rejected
P3	Facilitate knowledge sharing	Y	Enabling	Y	Enabling	Y	Enabling	Y	Enabling	Y	Enabling*	Not rejected
P4	Give local community and experts equal voices and standing	N	Limiting	Y	Enabling	N	Neutral	N	Limiting	Y	Enabling	Not rejected
P5	Account for contextual specificity and systemic complexity	N	Limiting	Y	Enabling	N	Neutral	Y	Enabling	Y	Enabling	Not rejected
P6	Appropriate scope	N	Limiting	Y	Enabling	Y	Enabling	Y	Enabling	Y	Enabling*	Not rejected
P7	Aim for transparency of relation with policy process	N	Unknown	Y	Enabling	Y	Enabling	Y	Enabling	Y	Enabling	Not rejected
P8	Aim for transparent research	Y	Neutral	Y	Enabling	Y	Enabling	Y	Enabling	Y	Enabling*	Not rejected
P9	Appropriate participant selection	Y	Enabling	Y	Enabling	Y	Enabling	Y	Limiting	Y*	Enabling	Not rejected
P10	Appropriate moment of citizen involvement	N	Unknown	Y	Enabling	0	Neutral	0	Neutral	Y	Enabling*	Not rejected
P11	Strive for a creative level of engagement practice	Y	Enabling	Y	Enabling	Y	Enabling	Y	Enabling	Y	Enabling*	Not rejected
P12	Strive for collaborative learning and building shared system understanding	N	Limiting	Y	Enabling	Y	Enabling	Y	Enabling	Y	Enabling	Not rejected
P13	Avoid mismatch rationale and goals.	Y	Unknown	Y	Unknown	Y	Unknown	0	Neutral	Y	Unknown	Uncertain

*) An asterisk indicates that the design principle was enabling, but not in all co-design workshops of the primary case study.

Third, co-design is a process of designing 'together' or 'with others'. It is this collectivity; the dynamics of social processes associated with engineering and policy-making practice that are of interest.

We characterize co-design in the coastal context as:

- A 'co-design activity' is a specific, collaborative, design-oriented effort, delineated in time and scope.
- Co-design activities involve designers and non-designers, citizens and/or disciplinary and practice-based experts creatively working together.
- A co-design activity facilitates integration across academic disciplines and public areas.
- Collaboration between participants can occur frequently in all phases of the co-design activity and throughout all phases of the decision making process.
- The scope of the co-design activities in this research fits in a context of coastal management and/or complex coastal systems.
- The specific contextuality of the coastal context prescribes tailor-made co-design activities and methods for finding appropriate solutions.
- The dynamic system complexity and understanding of the dynamic system complexity by various actors are considered key for finding good solutions.
- Underlying rationales for initiation of stakeholder-engaged co-design activities are based in idealistic or pragmatic rationales.
- Co-design activities are transdisciplinary, and can on the one hand involve interdisciplinary collaboration, as coastal management relies heavily on engineering disciplines, policy expertise and other scientific disciplines, and on the other hand collaboration with public participants, or both.
- Research on co-design occurs along two epistemic paths, and uses various knowledge sources, i.e., contextual and scientific knowledge sources.

This broad understanding of what co-design can be in a coastal management context was instrumental in the primary case study. In particular, the design of the co-design process for the case study of southwestern Texel is a manifestation of this conceptual understanding of co-design that was derived from the literature. Additionally, the literature review found no evidence to refute the underlying assumptions that the complexity of coastal management problems has contributed to the need for improved participatory support for coastal policy making. These underlying assumptions formed the starting point of this research.

RQ 2: What does theory say about the promise of co-design activities, and about how this can be realized in a coastal management context?

The theoretical promise of collaborative, design-oriented activities is described in terms of desired outcomes, considering system complexity in the coastal system. As such, the theoretical promise embodies a holistic way of conceptualizing reality underpinned by social-ecological systems thinking and transdisciplinarity.

Summarizing, we categorize the theoretical promise into three categories (next page). Note that a systems approach has proved to be useful in seeking to compare diverse activities, each exhibiting nested-scale problems with complex social (pt. 2) and bio-geophysical (pt. 1) dynamics. Additionally, the theoretical promise addresses the integrative nature and the linkages between the social, bio-geophysical and governance aspects that are relevant in a coastal context and knowledge sharing (pt. 3)– specifically addressing a transdisciplinary systems approach. This theoretical promise provides a conceptual lens to query the use of co-design in projects and guides the interpretation of the observed activities.

The theoretical exploration was also instrumental in the formulation of thirteen design principles. We reason that the promise of co-design in the coastal context as defined in this research can only be realized if the design of the co-design activity fits its specific coastal context. Although these design principles are quite generic, the craft in designing co-design activities for the promised outputs lies in connecting the design principles to the relevant coastal context. The design principles explicate the choices to be made when designing co-design activities:

- how knowledge from various sources is represented (P1, P2, P3, P4);
- choices regarding participant selection (P9);
- method choices (P11);
- phase of the design process, which is interknit with the purpose of the activity and its relation to the nested design process (P10);
- the ambition level for collaboration (P12);
- how trust issues are addressed (P6, P4);
- the scope of the problem, which is particularly problematic for the inherently dynamic coast, acknowledging the nested levels and scales (P5, P6, P7);
- reasons for initiating and doing co-design in the coastal context (P14).

To avoid redundancy, the thirteen design principles are not repeated here and can be found in Table 7-2, in the synthesis, and again in Table 7-3 below.

THEORETICAL PROMISE
OF CO-DESIGN IN THE COASTAL CONTEXT

1. Enhanced shared understanding of natural system complexity, for instance including the following elements:
    a. Addressing the interrelations between the geophysical and ecological subsystems.
    b. Within the geophysical system, advanced interpretation of geomorphological and hydrodynamic influences.
    c. Analysis of the character of the geophysical system's ability to maintain the diversity and quality of habitats characteristic of the ecological system.
    d. Analysis of environmental impacts on a complex coastal system, within practical spatial bounds.
    e. Improved representation of external influences, such as meteorological impacts and climatological impacts on the coastal system.
2. Enhanced shared understanding of social system complexity, for instance including the following elements:
    a. Representation of local and indigenous knowledge of the coastal system.
    b. Addressing the knowledge and perceptions of involved actors and non-involved local stakeholders
    c. Addressing the differences and interrelations between the social, institutional and governance subsystems.
    d. Early consideration of solutions that lie within the social components of the coastal system, especially relating to multi-actor complexity and institutional complexity
    e. Linking solutions to the policy context, by designing or implementing adaptive, long-term planning within feasible budget ranges and time frames, robust governmental changes.
    f. Addressing the constraints and opportunities offered by institutions (rules, norms, habitual procedures etc.) for potential solutions.
3. Improved knowledge sharing
    a. Sharing of scientific knowledge on the abiotic and biotic aspects of the coastal system, technical/engineering knowledge, and social science knowledge on policy making, institutions, and governance of the coastal system.
    b. Identification of interactions and interfaces between subsystems (social, governance, environmental).
    c. Knowledge exchange between inter- and transdisciplinary participant groups
    d. Using compatible scales by aligning solutions and appropriate time and spatial horizons.

RQ 3: How do co-design activities contribute to coastal management in practice?

Research question 3 set out to investigate the real-world contributions of co-design activities in the context of coastal management. In retrospect, this was a good question, but we were hampered by reality that offered few, if any, comprehensive co-design activities. We learned that co-design in the coastal context is in its infancy, and we have not been able to observe ongoing co-design processes for coastal management strategies.

Indeed, a key choice in the attempt to answer RQ3 was to learn from co-design in the coastal context by the design, organization, application and observation of such an activity. We did some pioneering work in the primary case study, undertaking an innovative co-design process on southwestern Texel, the Netherlands, concerning development of coastal management strategies for mitigating (the effects of) sediment erosion on the island of Texel.

Each of the three individual co-design workshops and the entire co-design process contributed to the outcomes of the primary case study. The observed outcomes in the primary case study include enhanced knowledge sharing, with varying scope and types of knowledge addressed. For example, scientific knowledge of bio-geophysical system, including past, current and future geo-morphodynamics in the North Sea affecting the Texel coastline, was deliberately shared and was taken into account by participants in designing solutions. In terms of social system complexity, the identification of factors that characterize Texel's unique value according to a wide range of stakeholders, in addition to the idenfication of actor values and when they are in conflict with each other, were recurring topics throughout the co-design process on Texel that influenced the designs. In terms of scope, participants considered the complexity of, and the interations between, social and ecological elements, including for instance the complicated relationship between (economically profitable) tourism and the quality and quietness of nature reserves. Additionally, ripple effects into the actor network were observed, especially in the learning and coalition building (see also Vreugdenhil, 2010; Cunningham et al., 2014). Indeed, one of the most striking outcomes of the co-design process on southwestern Texel was the insight in underlying assumptions of stakeholder preferences. Where the interests of one particular stakeholder (restaurant owner) were initially seen as a constraint, towards the end of the co-design process the more dominant constraining factor was identified as the water board's stance about the equal treatment of citizens and entrepreneurs. As such, the solution space was broadened from changing nourishment strategies (interventions in the natural context) to potentially changing municipal zoning rules (interventions in the institutional and governance context). What we did not observe, however, is whether that broader design space is actually used in a coastal decision making context. Moreover, the effects of the co-design process on coastal management practice were limited, because the primary case study experiment was explictly positioned as parallel to ongoing policy processes, and not directly linked.

The secondary activities show elements of co-design and show that some of the elements of its promise can also be found. From the secondary activities, we again see that lack of appreciation of knowledge of the specific local context does indeed result in faults in the final design outcomes. For instance, these types of knowledge gaps occurred in the activity Negril Bay, Jamaica (A), when lack of insights in the local stakeholders' perspectives, as well as specialized expertise on coral reefs, resulted in incomplete solutions for a coastal management problem in Jamaica. Nevertheless, even in activity A other learning effects occurred by the participants, including learning regarding the limits to the generalizability of nourishment strategies specific to the Dutch coast. Thus, we conclude that even when the outcomes of the co-design activity are limited, or when design principles have not been appropriately applied, learning effects from such failures can still occur.

The primary case study was a research study and not a policy study. Paradoxically, this meant that although the experimental set-up of this large case study allowed for many degrees of freedom in setting up the experiment, and of cooperation of relevant decision making bodies, it constrained our options to measure effects in decision making processes. We recommend further researching the actualization of the theoretical promise by studying co-design processes directly linked to the coastal management decision making processes, where they exist.

In conclusion, we learned that collaborative activities aimed at innovative coastal management solutions exist in the Dutch coastal management context, but specific co-design activities in this context are rare – especially co-design activities that encompass the full social-ecological systems view. In all collaborative activities, these led to knowledge sharing, and in several activities these led to the consideration of solutions that address different elements of the complex coastal system than just the bio-geophysical, including consideration of actor values and social complexity. As such, co-design activities have the potential to identify a broader space in which solutions can exist, which we saw in the observed collaborative activities that occurred in idea-generation phases of design processes. Additionally, the knowledge creation potential resonates with the concept of participatory management and fits with current ideals in coastal management (e.g., ICM, Dutch Delta program). It supports the premise that solutions (partially) lie on the interfaces between natural, social, and governance systems, especially for complex problems for which we seek solutions with long-term societal benefits.

RQ 4. How can the contribution of co-design activities to coastal management be strengthened?

Owing to the complexity and site-specific nature of coastal management problems, standard processes for co-design cannot guarantee success. In this research, we argue that while the design of the site-specific co-design activities needs to be contextual, the process to be followed in designing and refining such activities is generic. The design principles were formulated to give a general direction for designing co-design activities in specific coastal management contexts.

In practice however, a causal mechanism between design principles and envisioned outcomes, if existing, is indirect, implied and underlying, owing to the contextual complexity of such social activities. Indeed, the contexts indirectly influence co-design activities in convoluted ways that are not always explicit. Additionally, nested effects occur, and no single relation can be distilled from design to promised outcomes.

The design principles for co-design activities are manifestations of the design variables that transdisciplinary specialists have at their disposal in designing a co-design activity. Associated design variables include: reasons for doing co-design, representation of different types of knowledge; selection of participants; methods; the phase of the design process; the level of collaboration; trust; and the problem scope (see also the answer to RQ1).

The initial theoretical exploration was instrumental in the development of the thirteen design principles, of which the following twelve have been confirmed by the empirical observations. The design principles were used in designing the co-design activity on the primary case study on southwestern Texel. Additionally, the design principles are used to draw lessons from the secondary activities and the primary case study.

The empirical research did not yield enough results to confirm the thirteenth design principle. Nevertheless, evidence from the literature suggests that evaluating whether claimed benefits of participatory activities are obtained is important. Therefore, in a research context, explicating the stated purpose of the activity and the actual rationale for initiating the activity will improve transparency and allows for evaluation of these activities against these reasons.

We supplemented the design principles that were found in the theory with a principle on the importance of iterative reflection (P14). The design principle P14 stresses the importance of adapting the design of the co-design process to account for ongoing learning. Thus, this fourteenth design principle addresses the meta-level of design, and is supported by findings in the empirical research, most notable through the primary case study.

The synthesis (7.1.) already established the relevance of design principles P1-P12 to the observed secondary activities. We are therefore confident that taking these principles into account in the design of co-design activities in coastal management under similar circumstances, will result in more effective activities. Moreover, the design principles represent a normative attempt to prescribe how to design co-design activities in the coastal context.

The design principles are developed with the Dutch coastal context in mind. The Dutch coastal context has unique characteristics: the Netherlands is a Western democracy with a particular, consensus-seeking style of governance, with a legal and regulatory framework for decision making which also considers social and ecological factors, and with, generally, knowledge-rich conditions. These, and other, conditions influence the situations in which we engaged and/or observed. We expect that the design principle are applicable in other problem contexts under similar circumstances. Therefore, we invite other researchers to confirm or refute the design principles by applying them in other (similar) contexts.

Table 7-3. Twelve design principles from theory (not rejected)

#	Design principle
P1	Include local knowledge and local values
P2	Include scientific knowledge
P3	Facilitate knowledge sharing
P4	Give local community and experts equal voices and standing
P5	Account for contextual specificity and systemic complexity
P6	Appropriate scope
P7	Aim for transparency of relation with policy process
P8	Aim for transparent research
P9	Appropriate participant selection
P10	Appropriate moment of citizen involvement
P11	Strive for a creative level of engagement practice
P12	Strive for collaborative learning and building shared system understanding

Table 7-4 A thirteenth design principle (unconfirmed)

#	Design principle (unconfirmed)
P13	Avoid mismatch between rationale and goals (not confirmed)

Table 7-5 A fourteenth design principle (supplementary)

#	Design principle (supplementary)
P14	Allow for adaptivity of the design of the activity to account for ongoing learning

7.3. Insights for practitioners

We ask ourselves whether co-design can contribute to understanding and addressing coastal challenges of the future. As we stated before, co-design potentially fits with the existing trend in Dutch coastal management towards inclusion of multi-disciplinary and place-based knowledge in the management of the coastal environment. The in-depth case study on southwestern Texel has made such a co-design process that fits in the coastal context accessible to the engineering and coastal management community. Additionally, with the present push for the development of structures for participatory processes to facilitate dialogues between interested parties, officials and scientists, a plethora of frameworks help with evaluating these to facilitate learning, although evaluation does not always happen in management practice (McEvoy, 2019). However, not all evaluation frameworks are convenient or easy to use in practice. We offer the theoretical promise of co-design,

EIGHT WAYS TO FAIL

1. **Non-transparent research results in mistrust on the part of participants.** Opaqueness of the research protocol, eventual use of the results, the limitations of the activity and overpromising on the direct influence the results have on actual decision making will lead in mistrust on the part of the participants, both in the short-term (for the current activity) and for future activities.
2. **Untimely involvement of stakeholders.** Stakeholder engagement after the alternatives have already been developed may result in a sense of not being taken seriously and may contribute to the feeling of 'being unheard', or 'being manipulated'.
3. **Limited depth and breadth of stakeholder engagement**. Limited stakeholder engagement, i.e., lack of depth and with involvement activities relatively low on Arnstein's ladder of participation (1969) may again lead to participants feeling unheard and even disrespected.
4. **No sense of urgency for participants.** Even though the problem at hand is a real issue, when it exists outside of the lived experience of the (local) participants, they may not be concerned or engaged fully. If the problem scope is not shared or the urgency is not felt by the participants, they may not choose to participate.
5. **Ignoring power dynamics.** Whoever contributes to the activity, they bring their perspectives, values and specific sets of knowledge. Power imbalances can stifle group discussions, for instance by mutual interdependencies, gender differences, literary differences, or other power imbalances.
6. **Too narrow problem scope.** Challenges in coastal management, are often based in misunderstandings of scales and cross-scale dynamics, owing to the complex nature of the coast. A problem scope that is too narrow, ignoring the systemic complexities, can limit solutions to technological interventions. In our research we learned that through a wide systems view, a space can be created in which participants meet each other and communicate. Causalities are recognizable and discussed by almost all participants, independent of prior knowledge and background. An appropriate solution space also facilitates appropriate and integrated solutions that fit with the knowledge and background of the participants.
7. **Few resources for expert designs.** In some cases, the quality of the designed alternatives was less than expected. Gathering information, finding common ground, and the time-consuming nature of design processes are factors that limit the (outcomes of) co-design activities. Successful co-design activities are constrained by resources such as time and money, perhaps a hurdle for consulting and governance practice.

The empirical research did yield enough material to confirm the eighth way to fail. However, we include the reasoning here.

8. **Rationale mismatch with initiator's goals.** When normative assumptions do not match with the underlying rationale for choosing such a participatory style, the designed process will address something other than intended. Explicating the rationale for the participatory activity early and addressing the reasons for doing co-design makes the process more transparent, consistent with its aims, contributes to trust, and empowers organizers and participants.

against which activities can be interpreted in a simple and effective manner. Additionally, the theoretical promise can guide what choices to make in designing co-design activities in the coastal context, by serving as a list of criteria regarding the type of outcomes that can potentially be achieved.

This research found that co-design activities can provide useful input into the generation of design alternatives for practitioners on a project level. As is the case collaborating in workshops is time-consuming. When professional experts are invited to the table, the required budgets may need to increase. Collaboration and co-design in such early idea generation phases are therefore constrained by resources such as time and money, which is a hurdle for consulting and management practice. However, we have argued in this thesis that co-design activities contribute to solutions that fit safety requirements, as well as the needs stemming from the community and the natural system. Where professional experts were on occasion difficult to retain in co-design activities, local people are willing and (more than) able to volunteer their knowledge to changing their living environment. There is value in the investment of time and money to improve the overall quality and efficacy of the solutions designed in a co-design activity, also when that activity occurs in the early phases of decision-making processes.

Moreover, we argue that the process to be followed in designing and refining such activities is generic, and as such, a prescriptive guideline for designing co-design activities can be helpful in the process of designing site-specific co-design activities. While the design principles serve as a useful guide, they unfortunately do not provide a fail-proof recipe to develop sound and innovative collaborative designs. Moreover, it cannot be claimed that the application of one single design principle is instrumental to the success, perceived or real, of the activity. However, based on previous learnings and failings, something can be said about the reverse.

Indeed, the complexity of coastal management problems in practice means that co-design activities can fail in many ways. Because it is easier to lose reputation than to build it, and because trust is easily erodible and quite difficult to build up (Bontje, 2017), we identify eight key ways to fail for practitioners in a co-design activity in the box below. We have seen in for example secondary activity A (Negril Bay, Jamaica) that there is value in learning from failure. Therefore, these ways to fail are an attempt to guide practitioners in preventing unvarying types of failure of their collaborative design-oriented activities, for instance by doing the opposite of the design principles. These eight ways to fail are subjective, and are influenced by observed and made mistakes in case study research, which - as is often the case with mistakes - have given us insight in what not to do going forward.

7.4. Reflections

7.4.1. Reflections on the findings

We have investigated co-design activities within the Dutch coastal management network. We have drawn heavily on the professional network of Dutch coastal management involving key players, which gave informational insights in the current status quo of collaborative activities, but gave less insights specific to comprehensive co-design process with an appropriate scope. We have observed a lack of awareness of collaborative and participative design in this context, which - as discussed earlier - has limited the examples of co-design available for study. This observed lack of awareness in the Dutch contexts corresponds with findings in Slinger, Taljaard and d'Hont (2020), where a comparison of international case studies of (long-term) coastal management problems led to the conclusion that there is a need to design solutions in a different way: with actor-based knowledge, scientific knowledge, and a wider issue focus to fit the full social-ecological system and strengthen coastal management in the future.

Accordingly, we have done some pioneering work in this coastal context in the form of the primary case study. We have already reported that the co-design process on Texel worked at individual activity level and as a whole. Again, we don't know what this means for actual coastal management decision making. We therefore cannot be conclusive in this research about the full implications of co-design for the coastal management decision making, only about its potential, and we encourage other researchers to investigate further.

We have reported on what we found, but what didn't we see? In the primary case study and in the secondary collaborative activities, we did not observe power imbalances hampering communication. Additionally, no local participants withdrew from the co-design process, which indicates that there were reasons for them to return. Participant retention is something we were initially concerned about, given the indications of stakeholder fatigue on the island of Texel early in the research project. We assume that participant selection may have played a role. Additionally, reasons participants gave what they appreciated, included for instance the relevance of the discussed problem, the new insights they learned, new social connections, and that the trusted environment contributed to their commitment to the co-design process on Texel. These reasons follow from the specific choices we made in the co-design activity. The disciplinary experts were less inclined to return: in co-design workshop 3 the disciplinary experts were invited, but overwhelmingly unable to attend. Time and distance were a factor here, as well as scheduling conflicts – we chose to accommodate the local participants and have the final workshop before the high season for tourism starts. Eventually, this resulted in a trusted environment for co-design workshop 3, in which the participants could openly evaluate and critique the designs. Reflecting on the issue of participants' commitment to the co-design process, further research could apply a similar process that hinges less on disciplinary experts and experiment more with local expert co-design settings – while still accommodating the principle of putting sufficient, high quality scientific knowledge into the process.

Finally, the strong focus on Dutch coastal management practice in this research has formed a bias. Indeed, the collaborative activities (observed and undertaken) have drawn heavily on Dutch engineering expertise and models. This forms a bias in the thesis and limits the generalizability of the results to other contexts (see also Section 7.5.3.). Indeed, in other work, we identified situations that could benefit from integrating place-based and scientific knowledge into coastal management practice through transdisciplinary engagement (see Slinger et al., 2020; Slinger & Taljaard, 2020). As such, we speculate that the findings and the framework of analysis could be relevant internationally in the search for innovative coastal management solutions.

7.4.2. Reflections on designing co-design in the coastal context

Based on the clear conceptual distinction between content and process in policy analytic activities (see also Thissen & Twaalfhoven, 2001) and a broad literature scan, we constructed design principles for designing co-design activities in this thesis. Essentially, these design principles seem quite generic and process-oriented: they could for instance be applied to various other participatory policy processes. Indeed, as we stated before, the craft in designing a co-design activity that delivers the promised outcomes lies in relating the relevant coastal context to the design of the activity. This is where the particularities of the coastal context come in. However, looking back, we acknowledge that crafting and fitting in the particular coastal context in applying the design principles is not explicitly and clearly visible in the framework. We observe the following principles in particular that require knowledge of coastal bio-geophysical dynamics and careful design for its inclusion:

- P2. Include scientific knowledge
- P3. Facilitate knowledge sharing
- P5. Account for contextual specificity and systemic complexity
- P12. Strive for collaborative learning and building shared system understanding

To illustrate with an example from the primary case study, this craft is shown in the design choices that paid special attention to what knowledge was presented on what level, and which disciplinary experts were invited to present recent findings or assume an advisory role. As such, we see clearly that design choices on the content of the activity are equally essential as those on process. Understanding the specificity of the coastal context and how to connect the context seems to be essential in making co-design activities successful. Additionally, we see in this thesis that there is still a gap between the design principles and the manifestation of the principles in design choices. We encourage others to develop rules of thumb to craft such activities more fully.

In further reflecting on the validity of the design principles, we also did not see the confirmation of design principle P13, on the link between the rationale and the purpose of the activity. One could ask whether different rationales are problematic. They aren't necessarily and, more importantly, they are unavoidable in collaborative settings with transdisciplinary teams. However, this can become problematic when the purpose of the activity and the underlying rationale don't align, e.g., organizers run the risk of over-promising the effects of participative activities, and evaluation of the activity goes askew (see also Reed, 2009).

7.4.3. Reflections on the research approach

The framework of analysis in this research is underpinned by conceptualizing reality underpinned by policy analysis (Thissen & Walker, 2013; Walker, 2000), (social-ecological) systems thinking (see also Ackoff, 1979; Checkland, 2000, Redman, 2004) and transdisciplinarity (Bergmann et al., 2012). The research thus contributes to the scientific discourse on the potential of systems approaches in advancing multidisciplinary sustainability science (see also Reis, 2014, Slinger & Taljaard, 2020).

In accordance with the transdisciplinary stance, we note that the theoretical promise forms a framework in which different types of knowledge, such as model-based knowledge, local knowledge, and technical design knowledge, were explicitly recognized (see also Jahn, 2008; Max-Neef, 2005). However, even though focus on knowledge sharing is an essential aspect of transdisciplinary research, the high level of aggregation of the framework of analysis in this thesis does not explicitly and exhaustively address the practice of communication between people with different backgrounds and different types of knowledge. Communication challenges, such as for instance frame conflicts between disciplines and actors (see also Carton, 2007) or issues about the style of communication, can be answered by research that evaluates challenges to communication in close detail (see also Tromp, 2019).

The research employs as a primary strategy of inquiry a case study methodology, which was sufficient in learning across these different activities, especially once we realized that the secondary activities were not 'comprehensive' cases of co-design. Instead, they served to supplement our learning for the primary case study. Further research could address this shortcoming by choosing for smaller, more focused co-design experiments under controlled conditions to investigate best (and worst) practices of (elements of) co-design activities.

The diversity of the observed workshops presented its own particular challenge to learning. Each of the collaborative activities occurs in a different, nested coastal system and within different social, institutional and governance contexts. We chose to analyze the collaborative activities using a systems approach, which proved to give enough freedom to fit the inherently unstructured nature of co-design processes. But, partially owing to the systems approach, interpretation and analysis of the observed activities happened on a relatively high aggregation level. Further research employing finer analyses and evaluation using a detailed evaluation framework (see also McEvoy, 2019; Twaalfhoven, 1999) could provide perhaps more detailed insights in outcomes, use and effects of the activities in the short and long term.

7.5. Exploration of the research agenda

7.5.1. The role of co-design in policy making for multi-actor systems

Participation and collaboration have been framed and studied in many aspects of the policy process, but mainly concentrate on the problem-solving aspects of a multi-party collaboration (see also Bouwen and Taillieu, 2004). Design, and other creative practices, prove to be an interesting addition to the set of tools already present in multi actor systems problems. In this research we learn from the field of participatory design research (Ehn, 1989; Spinuzzi, 2005), but focus on co-design in the wicked problem context of coastal management. Collaborative, design-oriented approaches are numerous, but have not been formalized within the context of policy making for multi actor systems. We expect that further research on the quality and importance of relational practices can help in improving (the design of) the co-design process. Also, we expect that further investigation on the potential of co-design and other creative practices will shed light on its usefulness as a consensus-seeking approach, and this fits with the trend of making traditional engineering and design more participatory.

7.5.2. The role of actor values in participatory policy making

Participatory research often has a clear political-ethical orientation to empower participants (e.g., citizens, workers, users, stakeholders), and to include knowledge of the non-elite in decision making processes. Within public participatory research, citizen values are often unclear and muddled, but significantly affect method choices and outcomes. As such, eliciting values is found to be a useful way to improve dialogues between citizens, scientists and decision-making (see also Cunningham et al., 2014; Kothuis et al., 2014). Collaborative design approaches in this research include value elicitation, and analysis of the value space was shown to be useful in identifying value dilemmas and, subsequently, enriching discussions. As value distribution, and the values of marginalized citizen groups are under-researched in this field, research on clarifying and explicating values in participatory policy making approaches is needed. Additionally, the values of professional experts (so-called 'professional values') are also important in decision making processes, and we hypothesize that professional values may be less rigid than personal ones. New research can further expand on policy analysis evaluation by considering underlying values and rationales and making them more explicit.

7.5.3. Exploring the applicability in other contexts

The focus of this research on collaborative activities aimed at innovative coastal management solutions in the Netherlands raises the question whether the findings of this research are also applicable in other inherently dynamic contexts. Because the design principles from this research considers processes with citizen-scientist interactions, it would be interesting to test the design principles both in other coastal contexts and beyond the coastal context. Other coastal contexts with similar conditions are for example Northwestern European democracies, where decision making styles are consensus-seeking and participatory, similar to the Netherlands, but where the coastal communities are more loosely knit and smaller than in the Netherlands (see also Bontje, 2017). Additionally, moving to other Dutch professional expert networks concerned with ill-structured problems exhibiting nested bio-geophysical and social dynamics and long-term uncertainty, such as for instance river basin management, can also give an indication of the limits to generalizability of this research. Research in such and other human-environment systems, such as urban sustainability, integrated water management and integrated environmental management can extend insights in the applicability of the design principles beyond the current context of experimentation. Conversely, insights from these fields on applications of citizen-involved, design-oriented approaches can further inform the field of coastal management from these fields, for instance on citizen involvement on various areas and scales.

7.6. Co-design and its promise for bottom-up governance

Challenges for coastal management relate to a wide range of issues: flood defense infrastructures need to be resilient against sea-level rise and the expected increased frequency of storm surges; coastal areas are densely populated thanks to their attractiveness; and coastal and marine ecosystems' health depend on water quality and quantity.

We argue that co-design is a useful means when public and private actors move away from 'treating the problems' and towards first asking and analyzing what the problems actually are and collectively structuring the problems, values, and visions for the future. Co-design can be seen as a means to an end, i.e., co-design could be useful to help identifying the problems and associated design space in which coastal experts and policy makers can then design alternatives. However, in practice, coastal experts already have an idea of the problems and possible solutions for the issues, as it is their expertise area. Instead, it may be more useful to view co-design as a helpful means to educate both coastal experts and coastal communities on the wider systems view that can be adopted. Then, coastal experts can improve their communication to the policy makers, but also to the local communities about their suggested design alternatives. The limited use of co-design in practice can be hypothesized to have several reasons, including its relatively recent introduction in the coastal policy making sector, a lack of expertise in using the methods, the high complexity and resource requirements, or the limited usefulness of co-designed outcomes so far. Therefore, this research contributed by designing a co-design approach that is relatively easy to apply within limited time and resources, but at the same time (attempts to) meet the theoretical promise of collaborative design in participatory processes. Additionally, the framework to analyze co-design activities is intended to facilitate effective rather than deep evaluation of co-design activities, and so support ongoing learning on how to design and conduct co-design.

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APPENDIX

Appendix A.
Summary of underlying rationales

A summary of the findings of the analysis of the cross-comparison of rationales described in the Table below. We investigate some reasons for choosing a participatory approach in environmental management, and assess recurring claims and arguments for the use of participatory decision-making in environmental management, the broader field within which coastal management is nested (Taljaard, 2011). See Section 2.1.3.

Table A1. Summary of underlying rationales

Article	Remarks on the claims, reasons and evidence presented in corresponding article	Reasoning
Arnstein 1969, and alterna-tives to her ladder of participation (e.g., Biggs 1989, Pretty, 1995a,b; Goetz and Gaventa, 2001)	Arnstein's (1969) "ladder of participation" describes a scale of increasing stakeholder involvement, from passive dissemination of information ("manipulation"), to active engagement ("citizen control"). Much of the literature assumes that higher steps of the ladder should be preferred over lower ones (i.e., normative reasoning) (Arnstein, 1969; Evely et al., 2011). However, others view Arnstein's typology as a tool to highlight funda-mental differences between levels of abstraction, and recognize that different contexts require different levels of participation, thus focusing more on the suitability or 'fitness-for-purpose' (e.g., D'Hont, 2014; Richards et al., 2004; Tippett et al., 2007).	Normative or pragmatic , depending on author
Beierle (2002)	Beierle (2002) concluded based on his empirical meta-analysis from 239 case studies of stakeholder involvement in environmental decision-making, that intensive stakeholder processes are more likely to yield better decisions.	Pragmatic (Empirical)
Chess and Purcell (1999)	Chess and Purcell (1999) found that different methods (public meetings, workshops, or citizen advisory committees) did not affect the extent to which outcome and process goals were achieved. Success was more likely to be affected by (quality of) facilitation of discus-sions, planning quality, clarity of the set goals and good communication, versus lack of information and conde-scending attitudes towards participants.	Pragmatic (Empirical)
Habermas (1987)	Habermas (1987) suggests participation should be both 'competent' and "fair", equalizing power between participants and representing the full range of relevant stakeholders and (cf. (Renn, 2006; Webler et al., 1995; Webler & Tuler, 2000)	Idealistic (values and norms)
Koontz (2005)	An empirical, multiple case-analysis to study the signif-icance of the effect of stakeholder participation on the recommendations of policies in the US. The most signif-icant effect appeared in counties where both elected officials and the citizens were highly concerned about the issues (sense of urgency) and where there were strongly connected social networks addressing these issues.	Pragmatic (Empirical)
Martin and Sherington (1997)	Martin and Sherington (1997) argue for the demo-cratic value of stakeholder participation, by arguing that relevant stakeholders, who otherwise would by margin-alized, can be included in the decision- making process, thus promoting active citizenship, with benefits for the wider society.	Idealistic (values), linked with pragmatism (benefits for wider society)

Article	Remarks on the claims, reasons and evidence presented in corresponding article	Reasoning
Morinville and Harris (2014)	Morinville and Harris (2014) argue that failure to engage local actors frequently results in inadequate monitoring, ineffective governance, and poor outcomes, which results in arguments, both explicit and implicit, for participation. Also, the international development and water governance literatures echo a strong imperative for participation with a focus on effective governance in addition to considerations such as equity.	Links idealistic and pragmatic reasoning
Newig and Fritsch (2009)	Meta-analysis of 35 cases of participatory environmental decision-making in the US and Western Europe. Their empirical research found that the important determinant of effectiveness was the goals and interests of the participants, especially how strongly they favored environmental outcomes.	Pragmatic (empirical)
Okali et al. (1994)	Okali et al. (1994) distinguish types of participation based on categories of objectives for which participation is used (i.e., 'research-driven' and 'people-driven' participation) (cf. Warner, 1997; Michener, 1998).	Idealistic (norms)
Richards et al. k (2004)	Richards, Carter and Sherlock (2004) claim that stakeholder participation accounts for a diversity of values and needs in society and recognizes complexity in human-environmental interactions. Thus, stakeholder participation can increase public trust in decision-making and in the wider civil society, although transparency and acknowledgement of conflicting perspectives between stakeholders are necessary in the participatory process.	Idealistic (values and norms)
Rowe and Frewer (2000)	Rowe and Frewer (2000) focus on the nature of engagement, and conceptualize types of public engagements by communications flows between parties, in which 'participation' as two-way communication between participants and activity organizers.	Pragmatic (purposive)
Sultana and Abeyasekera (2007)	Sultana and Abeyasekera (2007) found statistical evidence that participation led to fewer conflicts between stakeholders and to greater uptake of conservation measures.	Pragmatic (empirical)
Tippett et al. (2007)	Tippett et al. (2007) explored existing participatory methodologies, and identified differences between methods to achieve different processes in participation to inform; design active engagement processes; consult; deliver implementation of management plans; or to monitor and learn from the effectiveness of participatory practice.	Pragmatic level
Multiple articles on empowerment of stakeholders	Many authors argue for participation enabling empowerment of stakeholders through (co-)generation of knowledge (Greenwood et al., 1993; Macnaghten & Jacobs, 1997; Okali et al., 1994; Wallerstein, 1999) and social learning (Blackstock et al., 2007; Pahl-Wostl et al., 2007). Empowerment is a value directly linked to democratic ideals, knowledge generation is more a normative objective/benefit.	Idealistic (values and norms)

Appendix B.
R script for value dilemmas and value space analysis (primary case study)

Applied in association with Prof.dr. Scott Cunningham of the University of Strathclyde

```
# read in the stakeholder feedback in the form of a table with rows as scenarios and columns as
actors
# do this twice, once for the upvotes and one for the downvotes
upvote <- read.table(“TexelDataUpvote.csv”, header=FALSE, sep=”,”, stringsAsFactors=FALSE)
downvote <- read.table(“TexelDataDownvote.csv”, header=FALSE, sep=”,”,
stringsAsFactors=FALSE)

# weight the upvotes and downvotes
# parameterize this to make it generalizable
salience = 3
ratings <- upvote + salience*downvote

# the columns have different norms which has the impact of giving some actors more sway
than others in the rating
# I’m not sure that that is a problem, but here’s how you would standardize
length = ratings*ratings
length = colSums(length)
# this is the length of each of the columns
length = sqrt(length)
# this standardizes the length
length = 10/length
# I’m not that worried about column length so I perform a less severe standardization
std = 0.5
ratings = ratings*length^std

# now complete assembling the data by adding column names and row names
colnames(ratings) <- c(1,2,3,4,5,6,7,8)
rownames(ratings) <- c(“A”,”B”,”C”,”D”,”E”,”F”,”G”,”H”,”J”,”K”,”L”)
scenarionames <- c(“Saint Tropez van het Noorden”,”St. Texel”, “Realistisch”,
“Texeltopia”,”DEBO: text in Twee Eilanden”,”Texel International”,”Mens Volgt de Natuur”, “De
Zeven Moelns”, “Kluitje Hoogbouw op de Hoge Berg”,”Den Helder Onder Laten Lopen”, “Zo
Natuurlijk Mogelijk Beheer”)
actornames <- c(“Sport en Recreatie”,”Natuur en Landscap”,”Historisch
Medegebruikers”,”Cultuurhistorie”,”Beleid, Bestuur en
Beheer”,”Toerism”,”Ondernemers”,”Bewoners”)
# nice to have the full scenario names
ratings[‘names’] <-scenarionames

# at this point we want to reduce the dimensionality of the data
# this does three things -- makes the findings more robust, enables analysis, and enhances
visualization
# reduced rows become “issue dimensions” -- all real scenarios are linear combinations of
these issues
# reduced columns become “actor coalitions” -- all real actors are linear combinations of these
coalitions
# I want to do this in three dimensions, since this is a practical limit for effective analysis
# you can read more about these procedures by investigating correspondence analysis and
multi-dimensional scaling
dim = 3
```

```
reduced = svd(ratings,3,3)
issues = as.data.frame(reduced$u)
issues[‘names’] <- scenarionames
issues

coalitions <- as.data.frame(reduced$v)
coalitions[‘names’] <- actornames
dimensionality <- reduced$d

# let’s examine the screeplot to get an idea of how high-dimensional the data actually is
# these are the eigenvalues of the matrix
plot(dimensionality, type=”o”)
# the highest possible dimensionality is 8, but there is a clear “neck” here around 3
# there is never a single clear answer about the underlying dimensionality of the data, but we
can calculate a measure
totald = sum(dimensionality)
percent_explained = (dimensionality[1]+dimensionality[2]+dimensionality[3])/totald
percent_explained
# for the case explored a three-dimensional space captures 67% of the variance

# now let’s interpret the coalitions
# this involves eye-balling the vectors for high loadings and low loadings
# the direction of the vector (positive or negative) is consistent, but arbitrary
coalitions

# the first coalition is basically the grand coalition; all are on-board except historical interests
# the second coalition is basically nature and homeowners; they must see themselves as
stewards of a relatively untouched, undeveloped place
# the second coalition is opposed by businesses, who perhaps want to increase economic
activity and tourists
# the third coalition is historical and recreational in character; for some reason it is opposed by
cultural interests

# now let’s interpret the issues
issues

# two islands and kluitjehoogbouw are clearly seen as (mostly) against the common interest
-- dystopias
# on the second issue set we have three heavily contested scenarios -- scenarios 1 and 6, versus
scenario 9
# These are “Saint Tropez and Texel International” versus “Kluitje Hoogbouw”
# The third issue is mostly “De Zeven Molens” and “St. Texel”

# The following arrow plot enables us to examine the space of coalitions and interests
plot(coalitions[,2],coalitions[,3],xlab=”Issue 2”,ylab=”Issue 3”)
arrows(0,0,coalitions[1,2],coalitions[1,3])
text(coalitions[1,2],coalitions[1,3],»Sport»,cex=0.7,pos=2)
arrows(0,0,coalitions[2,2],coalitions[2,3])
text(coalitions[2,2],coalitions[2,3],»Natuur»,cex=0.7,pos=2)
arrows(0,0,coalitions[3,2],coalitions[3,3])
text(coalitions[3,2],coalitions[3,3],»Historisch»,cex=0.7,pos=2)
arrows(0,0,coalitions[4,2],coalitions[4,3])
text(coalitions[4,2],coalitions[4,3],»Cultuur»,cex=0.7,pos=2)
arrows(0,0,coalitions[7,2],coalitions[7,3])
text(coalitions[7,2],coalitions[7,3],»Ondernemers»,cex=0.7,pos=4)
text(coalitions[6,2],coalitions[6,3],”Toerists”,cex=0.7,pos=4)
```

```
text(coalitions[5,2],coalitions[5,3],”Beleid”,cex=0.7,pos=4)
text(coalitions[8,2],coalitions[8,3],”Bewoners”,cex=0.7,pos=2)

# The lot shows a wide range of interests which are fundamentally at odds with one another

# The following plot enables us to examine the space of scenarios in light of interests
plot(issues[,2],issues[,3],xlab=”Interest 2”,ylab=”Interest 3”)
con.hull.pos <- chull(issues[,2:3])
polygon(issues[con.hull.pos,2:3], border=’blue’,lwd=2)
text(issues[6,2],issues[6,3],”F”,cex=0.8,pos=1)
text(issues[7,2],issues[7,3],”G”,cex=0.8,pos=1)
text(issues[8,2],issues[8,3],”H”,cex=0.8,pos=3)
text(issues[9,2],issues[9,3],”J”,cex=0.8,pos=1)
# the plot shows an incommensurate space of design choices

# Although the designs are incommensurate there are clear utopia and dystopian visions
# It would be nice to play with that
# Here we recode the points accordingly
plot(issues[,2],issues[,3],xlab=”Interest 2”,ylab=”Interest 3”)
utopian <- issues[issues$V1 < 0,]
dystopian <- issues[issues$V1 > 0,]
utopian_hull <- chull(utopian[,2:3])
dystopian_hull <- chull(dystopian[,2:3])

# Here we draw the utopian and dystopian design spaces
polygon(utopian[utopian_hull,2:3], border=’blue’,lwd=2)
polygon(dystopian[dystopian_hull,2:3], border=’red’,lwd=2)

#here we label the plots
text(utopian[1,2],utopian[1,3],”B”,cex=0.8,pos=1)
text(utopian[3,2],utopian[3,3],”D”,cex=0.8,pos=1)
text(utopian[4,2],utopian[4,3],”G”,cex=0.8,pos=1)
text(utopian[5,2],utopian[5,3],”C”,cex=0.8,pos=1)
text(utopian[6,2],utopian[6,3],”K”,cex=0.8,pos=1)
text(dystopian[3,2],dystopian[3,3],”F”,cex=0.8,pos=1)
text(dystopian[4,2],dystopian[4,3],”H”,cex=0.8,pos=3)
text(dystopian[5,2],dystopian[5,3],”J”,cex=0.8,pos=1)

#here we connect apparently related scenarios
segments(utopian[4,2],utopian[4,3],dystopian[5,2],dystopian[5,3])
segments(utopian[1,2],utopian[1,3],dystopian[4,2],dystopian[4,3])
segments(utopian[5,2],utopian[5,3],dystopian[3,2],dystopian[3,3])
segments(utopian[3,2],utopian[3,3],dystopian[3,2],dystopian[3,3])
segments(utopian[6,2],utopian[6,3],utopian[5,2],utopian[5,3])
segments(utopian[6,2],utopian[6,3],utopian[4,2],utopian[4,3])
segments(utopian[6,2],utopian[6,3],utopian[3,2],utopian[3,3])
segments(utopian[6,2],utopian[6,3],utopian[1,2],utopian[1,3])

#This analysis suggests that there is a single Pareto-optimal point somewhere between K and G
#However the space of value preferences are such that you will get very different designs
depending on who is part of the design process
#It would be nice to have a socially robust solution in the space of K
# Perhaps more scenarios could be envisaged in the facet of CKG, KGB, KDB and KCD
# The top facet of the design is more or less a “keep it undeveloped” access. The bottom left
facet an “local economic development” facet.
# The bottom right face is a “rental market and tourism”
```

Appendix C.
Value dilemmas and value space analysis (primary case study)

Applied in association with Prof.dr. Scott Cunningham of the University of Strathclyde

This steps involves exploration of variance in the stakeholder preferences through Pareto front analysis. Different expressions of the value dimensions are manifested in the various designs about the future of Texel. The co-designs of the future visions designed in workshop 1 encompass some of these expressions, which is shown in the tables below.

Utopian Expressions

Nature and Landscape v. Culture-historical	Culture History en inhabitants v. vs Policy, Governance & Management	Policy, Governance & Management. Entrepreneurs	
+	+	+	*No good expression*
-	+	+	D Texeltopia
+	-	+	B St. Texel
+	+	-	G Humans follow nature
+	-	-	K Utopia: as natural as possible.
-	+	-	*No good expression*
-	-	+	*No good expression*
-	-	-	*No good expression*

Dystopian Expressions

Natuur en Landschap vs Cultuurhistory	Cultuur History en Bewoners vs Beleid, Bestuur en Beheer en Sport en Recreatie	Beleid, Bestuur en Beheer vs Ondernemers	
+	+	+	I Nightmare: high-rise block on the Hoge Berg.
-	+	+	H The 7 mills
+	-	+	J Den Helder Onder Laten Lopen
+	+	-	E DEBO Texel split in two
+	-	-	*No Good Expression*
-	+	-	E DEBO Texel split in two
-	-	+	A St. Tropez of the North
-	-	-	F Texel International

Appendix D. Participants co-design workshop 2 (primary case study)

Fourteen disciplinary experts attended the workshop (experience with coastal areas across the globe, including the Netherlands, France, Australia, West coasts of North America, South East Asia, Australia.) The disciplinary experts are divided into the teams. As presented in the table.

Table B1: Discipline participation subdivided in three groups

	Domain	**Earth sciences domain**		**Social domain**		**Interfaces**
Expertise	**Specia-lization**	**Beach-dune morphology**	**Geology and coastal morphology**	**Coastal management and policy implementa-tion**	**Institutional design**	**Diverse**
Group subdivision	Group 1	yes	yes	Yes: coastal policy consultant	Yes	Geologist with knowledge of coastal planning
	Group 2	Yes	Yes	Yes , especially knowledge on operational governance and civil engineering	Yes	Landscape architect
	Group 3	Yes	Yes, espe-cially coastal engineering	Yes	Not present	integrated coastal management specialist with knowledge of insti-tutions, stakeholders and policy

Appendix E.
Descriptions of pacakages of measures

Output of co-design workhop 2, presented as handouts in co-design workshop 3 (primary case study)

Maatregelenpakketten

Group 1

Uitgangspunten. Deze groep overwoog een aantal factoren in hun brainstormsessie (figuur 1), met name de tijdshorizon van hun plannen. Ze ontworpen twee contrasterende visies: "mens volgt de natuur (MVN)" en "manage natuur (MN)", met als uitgangspunten de toekomstvisies die uit de eerste workshopronde naar voren waren gekomen.

Mens volgt de natuur (MVN). We creëren een zoute duinvallei vanuit de Mokbaai. De zoutwaterintrusie creëert een ander landschap met vallei-achtige omgevingen. Door het dynamische karakter krijgen de recreatie, de camping en de speeltuin een "pop-up karakter". Er is veel ruimte gelaten voor de invulling van dit ontwerp volgens het principe ZHLZMUJ ("Zoek het lekker zelf maar uit ja"). De in acht genomen tijdshorizon beslaat 30 jaar en biedt perspectief op de mate van dynamiek in het gebied.

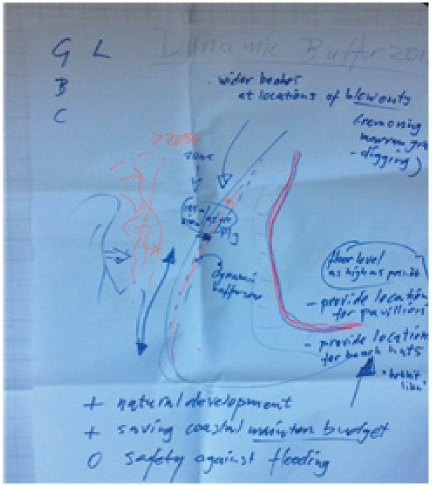
Manage natuur (MN). In dit beeld wordt de zelfde zoute duinvallei gecreëerd als in MVN en dezelfde tijdshorizon van 30 jaar wordt in acht genomen. Recreatie als een Landal winterpark met zwembad wordt geplaatst in het gebied om meer recreatie en meer recreatie in de winter te bevorderen. De Noorderhaaks wordt doorgestoken en de Razende Bol verandert in een Razende Duin: met duinaanplant wordt deze gefixeerd. Communicatie en educatie is nodig in dit gebied, net als aanpassingen in wet- en regelgeving, zoals bijvoordeeld de Legger.

Tijdshorizon. De geomorfologische tijdshorizon beslaat 30 jaar. De "horeca-cyclus" en het tijdsbestek van de gemeente zijn korten, waarschijnlijk minder dan 10 jaar. De dynamiek in het gebied, met name de zoutvallei, kent natuurlijk wel jaarlijkse invloeden.

Natuurwaarden. De zoute duinvallei schept een nieuw landschap waarvan er op Texel niet veel is. Een belemmering voor dit ontwerp kan de wettelijke status zijn, die eventueel moet worden aangepast. Daarnaast duurt het even voor een zoute duinvallei "aantrekkelijk" en mooi wordt. Hier moet rekening mee worden gehouden, o.a. in de communicatie naar toeristen en bewoners. De focus in deze ontwerpen ligt op de natuurlijke gebieden; de horeca- en recreatievoorzieningen zijn niet meegenomen.

Figuur 1. Mens volgt Natuur

Figuur 2. Manage Nature



Figuur 3. Tekening groep 2

Groep 2

Uitgangspunten. Deze groep maakten één lijst van maatregelenpakketen. Zij focusten op de wensenlijstjes van utopische toekomstvisies G, “Mens volgt de natuur”, en L, “Utopisch: zo natuurlijke mogelijk beheer”, plus op de natuurlijke ontwikkelingsaspecten van scenario’s B, “St. Texel”, en C, “Realistisch”. Wat gebeurt er als we niets meer doen? De periode van erosie rond Paal 9 wordt over 25-30 jaar opgevolgd door een periode van aanzet (accretion) . Tot die tijd zouden we wel 200 meter land kunnen verliezen, wat voor waterveiligheid geen gevolgen zal hebben, maar iets voor de natuurlijke waarden. Daarnaast zorgt voor kostenbesparingen voor kustmanagement, die weer kunnen worden geïnvesteerd.

Dynamiek en strandbreedte. We creëren een dynamische buffer zone, die verdwijnt over meer dan 25 jaar. Omdat de periode van aanzet pas over 50 jaar begint, moet het paviljoen zodanig mobiel zijn dat het weer richting de zee kan worden verplaatst. Op dit moment is het strand te smal. Bredere stranden zijn nodig om “blowouts” te stimuleren, net als minder steile hellingen, verwaaid zand en dynamische duinen. Dit kan ook handmatig worden gestimuleerd door grassen te verwijderen en zand weg te graven. Kunnen we ingrijpen om de erosie te stoppen en de periode van aanzet te vervroegen? Een nadeel hiervan is dat er een hoop (natuurlijke) waarden te vinden zijn op eroderende kusten. Zulke interventies zullen leiden tot influx in de duinsystemen.

Infrastructuur en mobiliteit. Nu is het probleem dat er een te smal strand is op een specifieke locatie. Waarom verplaatsen we niet de gehele “cluster” met voorzieningen naar het zuiden? De bereikbaarheidsproblemen die dan ontstaan moeten worden ondervangen met mobiele infrastructuur.

Investeringen paviljoen en strandhuisjes. De gespaarde kosten geven we ook uit aan Paal 9, dat een mobiel paviljoen wordt. We schrijven een bepaalde “vloerhoogte” (floor level) voor het paviljoen voor de komende 5 tot 10 jaar. “Hoe hoger het paviljoen, hoe langer je daar kan blijven”. We stellen een (jaarlijks veranderende) locatie beschikbaar voor de strandhuisjes (maar dat moet wel ergens op het strand blijven). De hobbit-achtige duinen worden als inspiratie gebruikt voor een nieuw te ontwerpen bezoekerscentrum. Niet op het Noorderhaaks, zoals in de utopische toekomstvisies maar hier op het eiland. Ook het ontwerp van de strandhuisjes wordt heroverwogen, zodat ze beter in het landschap passen.

Aandachtspunten techniek en wetenschap. Een schatting (kwantitatieve voorspellingen) van de morfologische ontwikkelingen zijn nodig. Daarnaast zijn nieuwe ontwerpen nodig voor “pop-up infrastructuur” en mobiele paviljoens. Bij het loslaten van zandsuppleties en een smaller wordend strand, zullen de mensen misschien geen veiligheid ervaren, zelfs als er geen verhoogd overstromingsrisico is. Communicatie over tijdshorizon en de veranderende dynamische processen over lange perioden is een speerpunt.

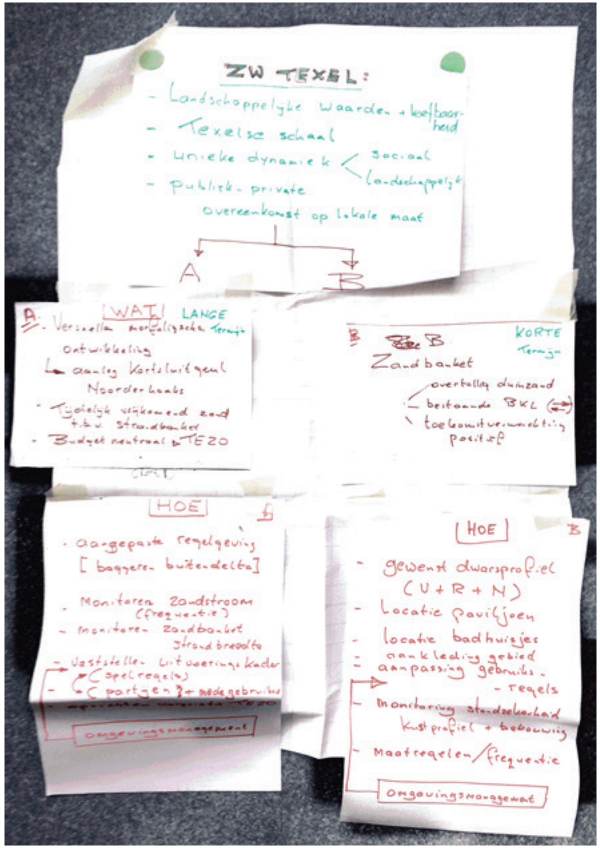
Groep 3

Uitgangspunten. Deze groep bleven dicht bij de realistische toekomstvisies. Uitgangspunten zijn de unieke dynamiek op Texel, zowel landschappelijk als sociaal. Een tweede uitgangspunt is dat het zand ooit arriveert op het strand, maar de vraag is wanneer. Als je naar de kaart van Texel kijkt, is het zuidelijke deel qua natuurwaarden erg verschillend van andere delen van Texel (zie het rode deel in figuur 6). Daarnaast wordt de invloed van de lokale bevolking behouden.

Keuzes. Er wordt een fonds opgezet: Texels Eigen Zandonderneming (TEZO), waarin inwoners zelf deelnemen. Texelaars weten wat het beste is voor Texel, en kunnen zo het budget inzetten. Willen ze een breder strand? Of het paviljoen verplaatsen? Een kanaal in de buitendelta graven om de zandmassa eerder aan land te laten komen? Een andere optie is om de eerste duinenrij te verlagen. Zo zal het strand breder worden en meer dynamiek in het gebied plaatsvinden. De keuze is dan tussen meer aanplanten en het controleren van de mobiliteit versus het loslaten van de natuurlijke processen.

Aanpassingen. Interventies in het fysieke systeem zijn pas mogelijk met aanpassingen in de regelgeving. Monitoring van de zandstroom en de strandbreedte zijn vereist, net als (hernieuwde) vastlegging van de locaties van het paviljoen en de strandtenten. De TEZO wordt gebonden aan spelregels: wie gaan meebeslissen en onder welke voorwaarden en restricties?

Figuur 4 & 5 Unieke waarden ZW Texel en interventies



Appendix F. Surveys for co-design workshop 3

To record evaluate the designed solutions of co-design workshop 2, the participants were asked to fill out these surveys. Additional surveys are discussed in the main text in Section 4.3.

Vragenlijst 1

TU Delft

Beste deelnemer,

Deze vragenlijst is onderdeel van:

"Terugkoppelsessie: Co-design van de toekomst van Texel-Zuid; dynamisch kustbeheer op een eiland in beweging", op 6 april 2017.

Zou u onderstaande vragen willen invullen en het formulier willen inleveren bij de organisatie?

Bij voorbaat dank.

Jill, Baukje, Floortje

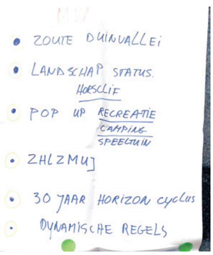
1. Naam deelnemer:

2. In de presentatie is verteld dat de resultaten uit workshop 1 middels een analyse zijn vertaald naar onderliggende waarden (zie figuur hieronder). Herkent u deze waardendilemma's als onderscheidende elementen in de toekomstvisies? Met andere woorden: "ziet u deze waardendilemma's terug in de elf gemaakte toekomstvisies?" Op welke manier? Licht a.u.b. toe.

Dynamische natuur	↔	Landschap en cultuurhistorie
Texelse identiteit, "eigen gebruik"	↔	Commerciele (massa)recreatie
Texelse ondernemersgeest, zelfredzaamheid	↔	Regelgeving, afhankelijkheid van "de overkant"

3. We hebben in de presentatie verteld hoe de disciplinaire experts de toekomstvisies uit workshop 1 hebben uitgewerkt in maatregelenpakketten. <u>Denkt u dat deze maatregelenpakketten uw waarde(n) goed hebben vertaald?</u> Gebruik hiervoor eventueel informatie uit de uitgedeelde documenten.

Vraag 3.1. Groep 1 Pakket 1: Mens volgt Natuur



Cijfer voor vertaling van uw waarden voor dit maatregelenpakket:
(Waardeer met een cijfer van 1 tot 5
(1 = heel slecht vertaald, 5 = heel goed vertaald)

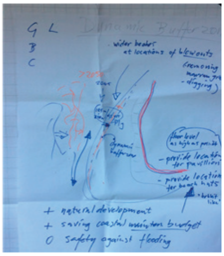
Opmerkingen bij dit maatregelenpakket:
Bijv.: wat vindt u van de maatregelen? Herkent u nachtmerriescenario's? Heeft u nog andere opmerkingen? Licht a.u.b. toe.

Vraag 3.2. Groep 1 Pakket 2: Manage Nature

Cijfer voor vertaling van uw waarden voor dit maatregelenpakket:
(Waardeer met een cijfer van 1 tot 5
(1 = heel slecht vertaald, 5 = heel goed vertaald)

Opmerkingen bij dit maatregelenpakket:
Bijv.: wat vindt u van de maatregelen? Herkent u nachtmerriescenario's? Heeft u nog andere opmerkingen? Licht a.u.b. toe.

Vraag 3.3. Groep 2 Maatregelenpakket



Cijfer voor vertaling van uw waarden voor dit maatregelenpakket:
(Waardeer met een cijfer van 1 tot 5
(1 = heel slecht vertaald, 5 = heel goed vertaald)

Opmerkingen bij dit maatregelenpakket:
Bijv.: wat vindt u van de maatregelen? Herkent u nachtmerriescenario's? Heeft u nog andere opmerkingen? Licht a.u.b. toe.

Vraag 3.4. Groep 3 Maatregelenpakket (o.a. Texels Eigen Zandonderneming TEZO)

Cijfer voor vertaling van uw waarden voor dit maatregelenpakket:
(Waardeer met een cijfer van 1 tot 5
(1 = heel slecht vertaald, 5 = heel goed vertaald)

Opmerkingen bij dit maatregelenpakket:
Bijv.: wat vindt u van de maatregelen? Herkent u nachtmerriescenario's? Heeft u nog andere opmerkingen? Licht a.u.b. toe.

--- Einde vragenlijst 1 ---

Vragenlijst 2

Beste deelnemer,

Deze vragenlijst is onderdeel van:

“Terugkoppelsessie: Co-design van de toekomst van Texel-Zuid; dynamisch kustbeheer op een eiland in beweging”, op 6 april 2017.

Zou u onderstaande vragen willen invullen en het formulier willen inleveren bij de organisatie? U bent niet verplicht deze vragenlijst in te vullen, maar we stellen het zeer op prijs.

Bij voorbaat dank.

Jill, Baukje, Floortje

1. Naam deelnemer:

2. Wat vond u van het hele co-design proces?

3. Wat vond u van de resultaten die het opleverde? Specificeer hieronder.

4. Was het proces inhoudelijk leerzaam? Heeft u nieuwe kennis opgedaan? Zo ja, welke?

5. Denkt u dat dit co-design proces effect heeft in de toekomst? Bijvoorbeeld op het gebied van kustbeleid? Zo ja, wat voor effect? Waarom?

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6. Voelde u zich gehoord tijdens de co-design workshop en de terugkoppelsessie? In welke mate? Waarom? Of waarom niet?

7. Heeft u uw inbreng vertaald zien worden?

8. Hoe waardeert u de inbreng van de andere deelnemers? Van de disciplinaire experts? Van de organisatie?

9. Indien mogelijk, zou u het anderen aanraden mee te doen met een dergelijk co-design proces?

10. Hoe vond u de opstelling op de locatie en de faciliteiten tijdens de workshops?

11. Wat was uw meest significante leermoment?

--- Einde vragenlijst 2 ---

Appendix G. Consent form for participants in

Because the research involved human subjects, we had the participants from the local community involved in the primary case study sign a consent form (in Dutch, below). This form and the research method are approved by the Human Ethics Review Committee of Delft University of Technology.

Verklaring vrijwillige deelname aan deze werksessie

Ik neem vrijwillig deel aan de werksessie onderdeel van het onderzoek "Co-Designing Coastal Channel-Shoal Sytems (CoCoChannel Sub-project C)" van Prof. Dr. Jill Slinger van de Technische Universiteit van Delft. De werksessie is ontwikkeld om met allerlei stakeholders gezamenlijk verschillende toekomstvisies te ontwerpen. De werksessie is onderdeel van een groter wetenschappelijk onderzoeksproject dat zich focust op co-design in kustgebieden. Aan de werksessie doen ongeveer 20 mensen mee, waaronder ikzelf. De werksessie vormt geen onderdeel van bestaande beleidsprocessen, maar is gekoppeld aan wetenschappelijk onderzoek.

Ik verklaar het volgende:

1. Ik neem vrijwillig deel aan het onderzoeksproject. Ik weet dat ik niet betaald krijg voor mijn deelname. Ik kan ten alle tijden en zonder consequenties van mijn deelname af zien.

2. Ik begrijp dat de meeste deelnemers de discussies interessant en inspirerend zullen vinden. Als ik me op welke manier dan ook oncomfortabel voel tijdens de werksessie, heb ik het recht om niet te antwoorden of zelfs mijn deelname te beëindigen.

3. Deelname bestaat uit aanwezigheid op een 1-daagse werksessie en op een terugkoppelingssessie op een avond, ongeveer 6 maanden later. Tijdens de sessies zullen er aantekeningen gemaakt worden. Om de aantekeningen later te kunnen controleren of aanvullen, zal er een geluidsopname gemaakt worden. Als ik niet opgenomen wil worden tijdens de werksessie, dan wordt mijn deelname onmogelijk.

4. Ik begrijp dat de onderzoekers bij het rapporteren over de resultaten van deze werksessies mijn naam niet zullen noemen en dat er tijdens de analyse van dit onderzoek vertrouwelijk met de data wordt omgegaan. Gebruik van opnames, aantekeningen en gegevens gebeurt volgens een standaard datagebruiksprotocol dat de anonimiteit van individuen en organisaties waarborgt.

5. Ik begrijp dat er een variëteit aan meningen geuit kan worden door de deelnemers aan de werksessie. Of ik het nu met andere deelnemers eens ben of niet, ik verklaar vertrouwelijk om te gaan met de meningen van andere deelnemers.

6. Ik begrijp dat de opzet van dit onderzoek gecontroleerd en goedgekeurd is bij de Ethische Commissie van de Technische Universiteit Delft. Indien problemen ervaren worden of er vragen zijn aangaande dit onderwerp kan contact opgenomen worden met de Ethische Commissie, via Joost Groot Kormelink van de Technische Universiteit van Delft (J.B.J.GrootKormelink@tudelft.nl).

7. Ik heb de aan mij versterkte informatie gelezen en begrepen. Al mijn vragen zijn naar mijn tevredenheid beantwoord. En hierbij verklaar ik, op vrijwillige basis, om deel te nemen aan deze studie.

8. Ik heb een kopie gekregen van deze verklaring.

____________________________ ____________________________

Mijn handtekening Datum

____________________________ ____________________________

Mijn naam Handtekening van onderzoeker

Voor meer informatie kunt u contact opnemen met Jill Slinger (j.h.slinger@tudelft.nl)

FIGURES

TABLES

ACKNOWLEDGEMENTS

In light of the topic of this dissertation, it seems weird to acknowledge the collaborating actors only on the final pages. I would like to take these pages to express my gratitude for the people who contributed to this research, in work and in life. Science is a collaborative effort, and this dissertation became a reality with the help of others.

I first and foremost would like to acknowledge the many participants who took part in this study and shared their time, knowledge and perspectives with me. I also would like to thank the colleagues who took part in the CoCoChannel project, for contributing their expertise in this interdisciplinary project, as well as the Building with Nature programme and Theo Saat of NWO for investing in this research. Special thanks to Baukje Kothuis and Felix Knipschild who helped in the realization of the case study of southwestern Texel. Finally, I am grateful to the members of the examining committee for their time in evaluating this work and providing guidance in improving it.

Special thanks to my supervisors, for providing guidance, encouragement and support throughout this project. Jill, your enthusiasm for the project. You have taught me a tremendous deal and I thoroughly enjoyed our collaboration, our endless conversations and the thinking we did together. Wil, thank you for your thoughtful comments and advice on this research. It has been a privilege working with both of you. I am also thanking to my colleagues at the Policy Analysis section, for providing a great and supportive place to learn. Marlies, Monique and Vera, thank you for your support. Special thanks to Sharlene and Sadie, for the fun we had sharing an office together and for your friendship. I am very grateful to have shared this experience with the both of you.

For as much as this thesis is a product of my mind, I am a product of those who are dear to me. I am immensely thankful for my friends, for your listening, patience and never-ending joyous entertainment – here finally is the dissertation you're never going to read. Marga, Suzanna, for your extra set of eyes. Sebastian, for your technical (and other types of) support. My parents, Julitta and Sebas, I'm thankful for your unlimited love and faith in me, and I am so grateful to have been raised in, and be a part of, our little, unconventional unit. Thanks to Pieter, for growing up to be my big brother and for your jokes. I dedicate this thesis to my sister Lieke, my perpetual opponent, who relentlessly and passionately argued with me no matter the topic. You contributed more than you'll ever know.

ABOUT THE AUTHOR

Floortje d'Hont was born on January 10, 1988, in Amsterdam, the Netherlands. After receiving her BSc degree 'Technische Bestuurskunde', Floortje went on to obtain the MSc degree 'Systems engineering, Policy Analysis and Management', both at the Faculty of Technology, Policy and Management (TPM) of Delft University of Technology in the Netherlands. Her work in the Bachelor and Master theses on the use of different types of knowledge in simulation modeling practice has fueled her interest in stakeholder engagement practices. In 2015, Floortje decided to stay with the Faculty of TPM to join the Policy Analysis section as a PhD candidate in the interdisciplinary research programme CoCoChannel, funded by the Dutch Research Council (NWO). During her stay at TU Delft, Floortje has enjoyed teaching in the Bachelor program 'Technische Bestuurskunde', the Master programs 'Complex Systems Engineering and Management' and Civil Engineering. Floortje continues to research and teach at the TU Delft.

Dissemination

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