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The role of knowledge in greening flood protection. Lessons from the Dutch case study future Afsluitdijk

Stephanie K.H. Janssen [a,b,*], Arthur P.J. Mol [b], Jan P.M. van Tatenhove [b], Henriëtte S. Otter [c]

[a] Scenarios and Policy Analysis, Deltares, P.O. Box 85467, 3508 AL Utrecht, The Netherlands
[b] Environmental Policy Group, Wageningen University, P.O. Box 8130, 6700 EW Wageningen, The Netherlands
[c] Subsurface and Groundwater Systems, Deltares, P.O. Box 85467, 3508 AL Utrecht, The Netherlands

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ABSTRACT

Greening flood protection (GFP) is an upcoming approach in coastal protection knowledge and policy. The central notion of this multifunctional concept is that natural processes, nature development and the dynamics of ecosystems are taken into account in realising flood protection. In practice, implementation of GFP is faced with multiple barriers, of which some are strongly related to knowledge. In this paper we aim to further our understanding of the realisation of GFP in projects by focussing on the role of knowledge and specifically looking at the interaction between knowledge related to different policy fields. We analyse under what conditions knowledge can enable GFP in projects. We apply a conceptual framework of knowledge arrangements (KAs)—drawing attention to the policy fields and the knowledge base— on the Dutch flood protection project Future Afsluitdijk. While the project aimed at more than just flood protection, this was not achieved. The case serves as an illustrative example of the struggle to organise knowledge processes for an integrated, greening flood protection design. We identify four main lessons on the role of knowledge: (1) knowledge development should take place at close distance to the policy process and include intensive interaction, (2) multiple design iterations are needed, (3) integration at policy level requires structural embedding to endure, and (4) tools are required that allow for an integrated assessment. Interestingly, the failure of integration between KAs within the project led to the development and re-organisation of the nature domain. As a result nature actors managed to pursue their goals, but in a different arena.

1. Introduction

All over the world deltas and coastal zones have to deal with increasing spatial pressures to accommodate multiple functions. Recreation, economic activities, housing, flood protection, nature conservation, agriculture and infrastructure all battle for space, while the available space in deltas is decreasing (Van Tatenhove and Hajer, 2001). Parallel to this, environmental awareness and interests are increasing in society. Economic and development processes are "increasingly analysed and judged, as well as designed and organised from both an economic and an ecological point of view" (Mol, 2002 p.94). In the field of flood protection and coastal management such an 'ecologically induced transformation' (Mol, 2002) has resulted in practices and discourses of so-called greening flood protection (GFP). GFP as a new upcoming approach stresses that natural processes, nature development and the dynamics of ecosystems are taken into account in realising flood protection. Examples where this new flood protection discourse is put into practice are the use of vegetation for wave attenuation (Borsje et al., 2011; Gedan et al., 2011), (large) sand nourishments for coastline maintenance (Janssen et al., 2014; Stive et al., 2013; van den Hoek et al., 2012) and oyster beds for protection against erosion and stabilizing sediment (De Vries et al., 2007; Piazza et al., 2005). Conventional flood protection, for example in the form of traditional dams, dikes, storm-surge barriers, breakwaters and the like, differ from measures that facilitate GFP. The latter have a pro-active stance towards the ecosystem rather than a defensive approach by minimizing potential negative effects on the environment. GFP aims to (pro)actively involve and include nature and environment in optimising flood protection. The GFP discourse has led to a variety of concepts in literature and practice, such as building with nature (De Vriend and Wesselink, 2009; van den

* Corresponding author. Scenarios and Policy Analysis, Deltares, P.O. Box 85467, 3508 AL Utrecht, The Netherlands. Tel.: +31 6 20779589; fax: +31 (0)88 335 7856.
E-mail addresses: Stephanie.janssen@deltares.nl (S.K.H. Janssen), Arthur.Mol@wur.nl (A.P.J. Mol), jan.vantatenhove@wur.nl (J.P.M. van Tatenhove), henriette.otter@deltares.nl (H.S. Otter).

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Hoek et al., 2012; van Slobbe et al., 2013), ecological engineering (Borsje et al., 2011; Mitsch and Jørgensen, 2003), working with nature (PIANC, 2011), ecological enhancement (Naylor et al., 2012) and ecosystem-based management (Katsanevakis et al., 2011; Knol, 2013). But all these approaches work with more or less the same principles and ideas, and intensively exchange these ideas.

In the last decade GFP has gained increasing attention. The common knowledge base on possible alternatives for greening flood design is built for a variety of physical settings (Borsje et al., 2011; Naylor et al., 2012), and GFP is increasingly present in national and international policy documents and in the objectives of individual flood protection projects. Yet, the implementation and realisation seems to move forward less swiftly (Borsje et al., 2011). Combining nature protection or development with flood safety objectives in flood protection projects requires an integrated and multifunctional approach, but in practice numerous barriers complicate the realisation of such multifunctional infrastructures (Katsanevakis et al., 2011; Mulder et al., 2011; Van Broekhoven and Vernay, 2011).

Central to the implementation of GFP is the role of knowledge. Besides functioning as an important resource it structures the involvement of actors and their specific views (Mol, 2008; Toonen and van Tatenhove, 2013). Knowledge is thus an important factor enabling or constraining decision-making. GFP requires cooperation among a diverse range of disciplines, – including engineering, ecology, (geo-)morphology, climate science, physics, economics and others (O'Toole and Coffey, 2013) – and the development of innovative and integrated perspectives on flood management practices. A substantive body of literature exists on knowledge in decision making with a focus on the transfer of science/knowledge to policy (e.g. Holmes and Clark, 2008; McNie, 2007; Turnhout et al., 2007) and combining different types or disciplinary knowledges (e.g. Rinaudo and Garin, 2005). The multidisciplinary nature of GFP however, draws our attention to the inherent relation between knowledge and policy fields (Edelenbos et al., 2011; van Buuren and Edelenbos, 2004) and to the interaction between these knowledge-policy fields. In particular the latter is a topic only incidentally addressed. The prevailing policy discourse, the dominant actors with more or less resources, and the relevant rules and regulations of a policy field structure the role and type of knowledge in that particular policy field. GFP projects are characterised by different policy fields meeting each other and subject to changing governance settings (Korbee and Van Tatenhove, 2013). Therefore, the integration of knowledge disciplines in designing measures goes beyond 'simple' overcoming epistemological barriers. In fact, as central in our conceptual framework (Section 2), it is a matter of double integration: of knowledge and of the policy contexts.

In this paper we aim to further our understanding of the realisation of GFP in projects by focussing on the role of knowledge and specifically looking at the interaction between knowledge related to different policy field. The main question this paper seeks to address is: how and in what ways does knowledge enable GFP in projects? In order to answer this question, we apply a qualitative case study approach (Section 3) and analyse the Dutch flood protection project Future Afsluitdijk[1] by means of our conceptual framework of knowledge arrangements (KAs) (Section 2). This project aimed to accomplish "more than just safety"[2] (Ministerie van Verkeer en Waterstaat, 2007) and a range of attempts were undertaken to include nature development in the flood protection design.

[1] In Dutch: Toekomst Afsluitdijk.

[2] Safety refers to matters of safety against flooding. In this paper we will use the term flood protection.

The paper is structured as follows. In the next section we introduce our conceptual framework and explain the underlying theoretical foundations. In section 3 we discuss our case study design. In the result section (section 4) we discuss the interaction among KAs as happened in our case study. These results are then discussed in section 5 and we finish the paper by drawing conclusions upon the role of knowledge for GFP (section 6).

2. Conceptual framework: knowledge arrangements

Knowledge is a crucial asset in the decision-making process of developing infrastructure for flood protection. In analysing problems, finding and designing solutions, following legal procedures and generating public support knowledge is indispensable (Van Buuren et al., 2010). The involvement of a wide variety of actors, with different and diverging interests and backgrounds, often results in debates on knowledge during decision-making processes (Koppenjan and Klijn, 2004). This is in particular relevant for coastal management. The complexity of coastal environments together with diverse uses and presence of multiple stakeholders makes bringing together of different knowledges a considerable challenge which has often turned out ineffective (Clarke et al., 2013). Understanding coastal development from a knowledge perspective draws attention to particular challenges such as the presence of different and fragmented forms of knowledge, sensitivities around information, the political site of knowledge and uncertainties in understanding (O'Toole and Coffey, 2013). Also such a perspective improves the understanding of knowledge as dynamic and non-linear as opposed to linear 'research and application' (Coffey and O'Toole, 2012; Van Kerkhoff and Lebel, 2006). To overcome knowledge conflicts and to provide 'useful' information or knowledge to policy makers, a large body of research is devoted to closing the gap between science and policy and to overcome epistemological barriers either from a science technology studies or sociology of science perspective (Holmes and Clark, 2008; McNie, 2007; Turnhout et al., 2007) or by proposing actual frameworks to connect scientists and decision-makers (De Jonge et al., 2012). In this paper on the role of knowledge in GFP, attention is on the embeddedness of knowledge in particular policy fields and the related interactions between knowledge and policy.

Within a single policy domain, interactions between knowledge agents and policy makers are frequent and both have often similar orientations and backgrounds (Edelenbos et al., 2011). In addition, frequent interaction allows for sharing of tacit knowledge with more effective knowledge as a result (Hunt and Shackley, 1999). This phenomenon is noticed in literature and captured for example by concepts as 'knowledge coalitions' (van Buuren and Edelenbos, 2004), 'knowledge arenas', 'ways of knowing' (Lejano and Ingram, 2009), or 'knowledge systems' (Roling and Jiggins, 1998). A systematic analysis however of *interaction* among these knowledge-policy fields, is lacking or does not include the policy context of knowledge (e.g. Hunt and Shackley, 1999). Here lies the contribution of this paper.

We capture the interaction between knowledge realms and policy fields within a specific domain by the concept knowledge arrangements (KAs). In GFP, KAs related to nature and to flood protection interact and clash with each other. We will analyse these interacting KAs.

2.1. Knowledge arrangement

Knowledge and policy are not isolated fields, but they interact and overlap in a 'fuzzy boundary area' (Turnhout et al., 2007). Knowledge development in policy processes is a two level game where knowledge influences policy processes and outcomes and policy making influences knowledge generation and articulation

(Koppenjan and Klijn, 2004). In other words, knowledge development and articulation is embedded in its (policy and other) contexts (Nowotny et al., 2001) and thus will differ in both content and orientation among locations of development (Eshuis and Stuiver, 2005). The concept of KAs is based on this recognition that knowledge and policy are interrelated and specific for a particular domain.

The concept of KAs builds upon the idea of policy arrangements as developed by Van Tatenhove et al. (2000). This approach builds on the 'duality of structure' developed by Giddens (1984) and balances structural and discursive elements of policy processes (Wiering and Immink, 2006). A policy arrangement is a "temporary stabilisation of content and organisation of a particular policy domain at a certain policy level or over several policy levels" (Van Tatenhove et al., 2000 p.54). It is identified and analysed by four interrelated dimensions: (1) actors and coalitions involved in policies, (2) discourses that capture views and narratives of these actors, (3) resources applied by actors (e.g. money, knowledge, authority, facilities), and (4) (formal and informal) rules of the policy game (Liefferink, 2006). While knowledge in the policy arrangement approach is recognised as a power resource in a policy domain, the way the knowledge base is created, interpreted and used is not explicitly dealt with. We define a knowledge arrangement as the dynamic interdependent constellation of a knowledge base and the policy arrangement within a specific domain. Following Hommes (2008) and Hommes et al. (2009) we define a knowledge base as a collection of knowledge sources (i.e. research reports, models, data, practical experiences, etc.) that have been made explicit and are related to a specific policy arrangement.

2.2. Multifunctional infrastructure development: interacting knowledge arrangements

In greening flood protection, different KAs interact with each other (Fig. 1). The type of interaction between KAs determines the possibilities for an integrated design. Four types of interaction among KAs can be distinguished: separation, cooperation, integration and unification. Separation reflects no interaction between KAs. Knowledge base and policy development happen within different isolated domains without any sharing or communication back and forth. Cooperation is a form of interaction in which KAs do communicate and are mutually aware of (policy and knowledge base) developments in the other domain. Developments in designing and decision-making may be attuned and mutual influencing and a common agreement or 'position' with respect to GFP is conceivable. When KAs cooperate they do not merge into one new KA. The third form of interaction is integration in which KAs do merge, but will not dissolve. Integration means that a new arrangement emerges as a combination of elements of the two former arrangements. Actors cooperate in one team or organisation, and resources and approaches are shared and collective, while the home-institutions remain in place. The initial KAs disappear and are replaced by a new KA when interaction leads to unification. Within the boundaries of a single project, integration is the most far-reaching form of interaction achievable. Unification is the result of a process that exceeds a single project as it requires multiple projects, policies and societal developments over a longer time.

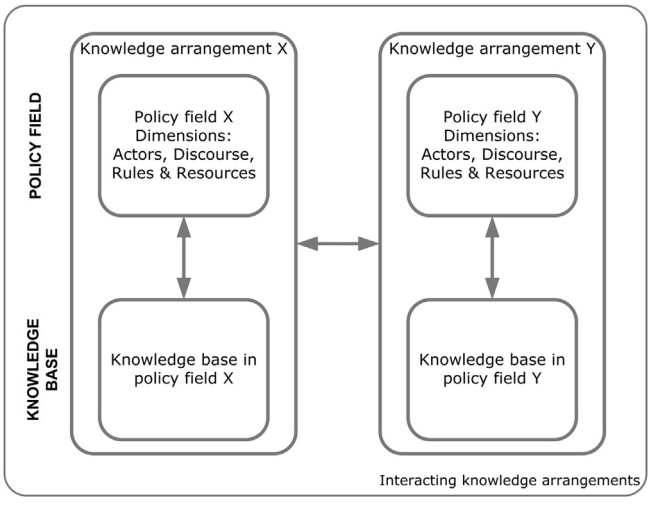


Fig. 1. Interacting knowledge arrangements.

KAs are inherently dynamic as changes in one dimension are likely to result in changes in another (Liefferink, 2006). The introduction of new reports, actors, scientific insights, legislation, or resources will evoke change in the arrangements to a smaller or greater extent. The confrontation between KAs is also an incentive for change (Lejano and Ingram, 2009; Wiering and Immink, 2006) and can be either constraining or enabling greening flood protection (Koenig-Archibugi, 2002).

Because GFP requires collaborative action of distinct domains, knowledge from different domains should be integrated or become 'inclusive': "[inclusive knowledge] paves the way by delivering a joint knowledge base and a shared frame of reference" (van Buuren, 2009 p. 230). Sectoral approaches are less appropriate to lead to GFP (Katsanevakis et al., 2011) and hence an integrated form of KAs is required.

3. Case study design: selection and method

In this section we discuss the selection of the project Future Afsluitdijk as our case study and the methods we applied.

3.1. Case study area

The ambition of the project Future Afsluitdijk was "to do more than just safety" (Ministerie van Verkeer en Waterstaat, 2007). In fact, the project was to serve as an 'icon' and show the advantages of a synergy approach (Instituut SMO, 2008; Ministerie van Verkeer en Waterstaat, 2007). One explicit goal relates to combining flood protection with nature development, often labelled 'building with nature'. The objective of the project and the integral approach applied makes the case an interesting example for studying the implementation of GFP.

The Afsluitdijk is a dam situated between the Wadden Sea and Lake IJsselmeer and counts as one of the main icons of Dutch coastal engineering (Fig. 2). Following the big flood in 1916 this dam was constructed to improve flood protection and create agricultural land. It had big consequences for the geographic development of the northern part of the Netherlands (De Jonge, 2009). The dam closed off the Zuider Sea and created Lake IJsselmeer in the north of the Netherlands. Lake IJsselmeer is the largest fresh water body in the Netherlands (1 200 km^2) and an important (buffer) for fresh water supply. Furthermore, it facilitates shipping, sand mining, and fisheries. The important natural value of the lake is under stress and central to improvement is the recovery of the transition between the fresh water in Lake IJsselmeer and the salt water in the Wadden Sea (Ministerie van Infrastructuur en Milieu, 2009). Such a salt-fresh water transition is also essential for the natural value of the Wadden Sea (Raadvoor de Wadden, 2008). The Wadden Sea is a nature site of global importance and designated as World Heritage Site for its unique natural value (Kabat et al., 2012). It is indicated as a Natura 2000 site in order to maintain and improve biodiversity in the area. The main policy objective for the Wadden Sea is

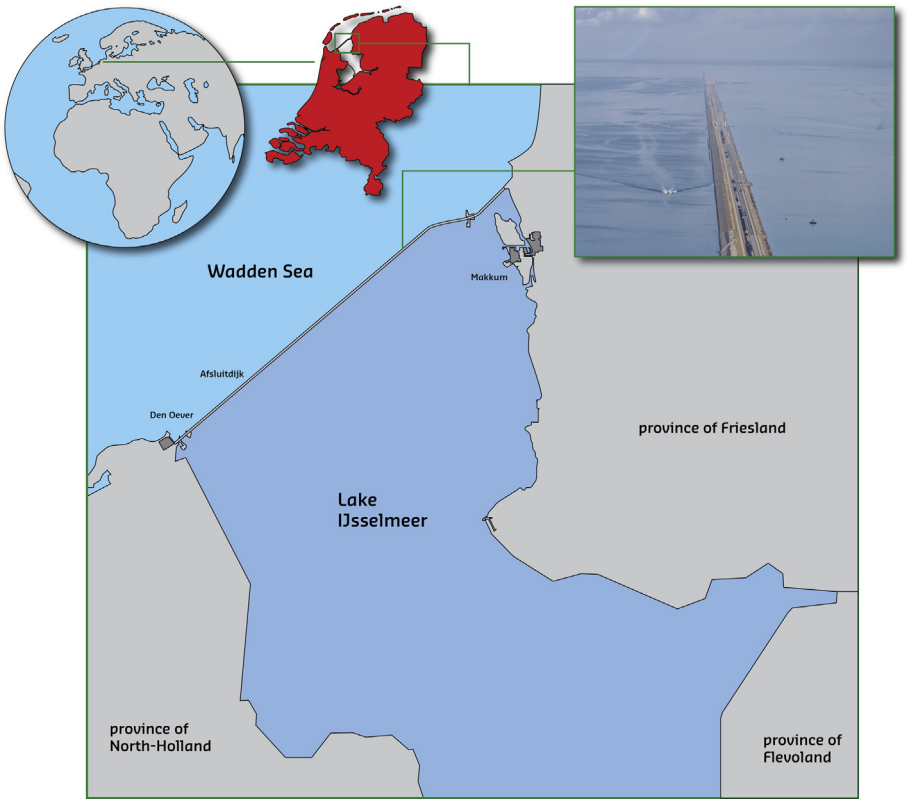


Fig. 2. Overview of the Afsluitdijk. The Afsluitdijk is located in the north of the Netherlands and closes of the salt Wadden Sea from the fresh water Lake IJsselmeer. At the north-east side the dam is connected to the province of Friesland, at the south-west to the province of North-Holland. At the north-east side of the dam the Lorentz sluices (locks and drainage sluices) are located, in the south-west the Stevin sluices (locks and drainage sluices). The dam contains a road and a bicycle track and accommodates some recreational functions.

defined as: "the sustainable protection and development of the Wadden Sea as nature area and maintenance of the unique open landscape" (Ministerie van VROM, 2007, p.9). Since the 1960s the ecological value and human impact in the area – e.g. fisheries, gas mining, tourism – have been of growing concern (Kabat et al., 2012). Of particular importance in this process was the Mazure committee who advised negatively on reclaiming the Wadden Sea (Waddenzeecommissie, 1974).

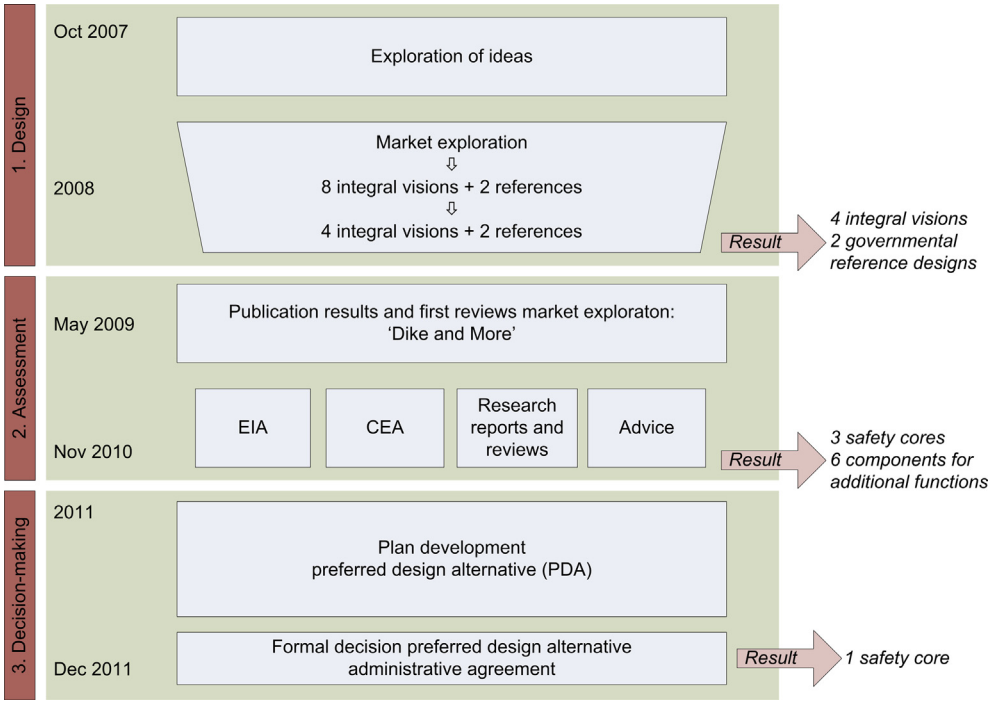


Fig. 3. Overview of process Future Afsluitdijk towards a preferred design alternative. The project documents underlying this Figure are listed in Appendix 2.

Today, the 32 km long Afsluitdijk still counts as a mastery example of Dutch coastal engineering skills. After doing its duty for over 80 years, in 2006 the "grand old lady" of Dutch coastal engineering no longer meets the flood protection standard (withstanding a 1/10.000 year storm). The project 'Future Afsluitdijk' (in Dutch *Toekomst Afsluitdijk*) started in 2007 in order to reinforce the dam.

3.2. Methods

To study the project Future Afsluitdijk we used a qualitative case study approach based on data triangulation using five different methods for data gathering. As sources of data we used: seven in-depth formal interviews, multiple informal interviews with a broad range of stakeholders, (participatory) observation through attending public and project meetings, and extensive analysis of project documentation. In addition, we discussed the results of the case study analysis and earlier versions of the paper with project participants from the province and the ministry in order to validate observations and interpretations made.

The principal researcher was involved in the project from June 2010 onwards, when the outcome of the project was still unknown. Our real-time data collection (when the project unfolded) yielded insight into the daily practice of the project and specific circumstances that could perhaps not all have been recaptured in interviews or formal documentation afterwards. The participating researcher was provided access to all project documentation, including internal writings, minutes of meetings, e-mail correspondence, (formal) reports etc. Formal interviews were held with two ministerial representatives, one provincial representative, two representatives of nature organisations, one consultant hired by the ministry and one respondent of a market party. Five of the interviews were held in November 2011 (just before the formal decision on the preferred design alternative) and two were held one year later. The formal interviews had a semi-open character and were based on the clean language approach. This approach is rooted in psychology and now applied in many fields including education, health, business and research. Clean language is about gathering information by means of asking 'ultra-open' questions that contain as few assumptions and metaphors of the respondent as possible (Sullivan and Rees, 2008). The story of the respondent is therefore minimally mingled with the ideas and words of the interviewer, and the respondent has the maximum freedom to choose the answer he considers suitable. The interviewer structures ideas and opinions of the respondent and encourages the person to elaborate (Sullivan and Rees, 2008; Van Helsdingen and Nijburg, 2012). This interview approach aims to minimise bias by ruling out the assumptions and intentions of the interviewer, which is highly relevant for this particular situation where the researcher is intensively involved in the project.

Data analysis was informed by our conceptual framework of KAs, which was leading in categorizing and organising the extensive data set. This was an iterative process where we combined the diverse and multiple sources of information available. Based on this we extracted the discourses applied, the leading rules and regulations, the actors that played a role and their interactions, the resources that were available and the knowledge base that was constructed.

Our analysis of the case study stops after the selection of the preferred design alternative. Plan and project development however continued after that and currently the minister intends to decide on these in 2015. The project expects to start realisation in 2017, with an anticipated end date of 2021.[3]

[3] Source: http://www.rijkswaterstaat.nl/water/plannen_en_projecten/vaarwegen/ijsselmeer/project_afsluitdijk/index.aspx, accessed on 13 December 2013.

4. Results

In this section we describe the interaction that occurred among knowledge arrangements (KAs) in the case study Future Afsluitdijk. As the interest is in greening flood protection the focus is on interaction between the two KAs related to flood protection and nature. However, the project Future Afsluitdijk was not directed at combining flood protection and nature alone or specifically. Rather, the project aimed to combine a broad range of functions (including energy, recreation, agriculture and nature).

The case study Future Afsluitdijk can be divided into three successive phases: design, assessment, and decision-making (Fig. 3).

The design phase started with a broad exploration of possible ideas for the future dam. The main question was how the Afsluitdijk could fulfil multiple functions. Over 200 people participated in workshops that led to a wide range of new and innovative ideas and functions, including large iconic structures, aqua-culture, a road surface with integrated solar power, wetlands in the Wadden Sea, and even reopening the Afsluitdijk in order to allow for tidal dynamics (Instituut SMO, 2008). These ideas served as input and inspiration for a so-called 'market exploration'. Market parties were asked to develop visions for the Afsluitdijk, resulting in four very diverse integral visions (Appendix 1). In parallel to the design activities of market parties, the ministry of V&W[4] (ministry of Transport, Public Works and Water Management) developed two 'governmental reference designs': an overflow-resistant dam and a robust traditional dam (see Appendix 1). These designs focused primarily on flood protection.

The 'assessment' phase was structured by formal procedures, such as environmental impact assessment (EIA) reporting, cost effectiveness analysis (CEA), and the assessment framework. In order to compare the ideas of market parties, the integral visions were split into a 'core' relating to flood protection and several 'components' relating to additional functions (e.g. nature protection or creation, sustainable energy, spatial quality). This resulted in four different cores—a conventional dam, an overflow-resistant dam, a storm shield and sand nourishment—and a large range of components, among others silt agriculture, a sustainability centre, naviducts, tidal and flow power stations, bridges, fresh-salt water transitions and wetlands. In a period of almost two years,[5] these cores and components were assessed on their feasibility. This approach resulted in three conclusions: none of the integral visions was feasible as a whole, the elimination of the sand nourishment core, and the selection of a number of components requiring further study.

In the 'decision-making' phase the selection of a 'preferred design alternative' (PDA) was central. To be included in the PDA each core and component should be sufficiently 'substantial', which meant including a plan, a responsible party and an indication of the financial consequences. The limited available financial resources of the ministry and the urgency to improve the dam led to a change in organisation. The ministry emphasised to be responsible for flood

[4] In October 2010 the Ministry of V&W and the Ministry of Housing, Spatial planning and the Environment (VROM) merged into a new ministry of Infrastructure and Environment (I&M). In this paper we refer to 'the ministry of V&W' or simply to 'the ministry'. Within the ministry of V&W two different departments (directorate generals, DG's) are involved in the project: DG Rijkswaterstaat and DG Water. In this paper we will not discuss the division of roles, responsibilities and tasks among the DG's but directly refer to the ministry of V&W.

[5] The assessment phase was relatively long. In particular the results of the CEA were time-consuming, and delayed by the fall of the Dutch government in February 2010. The CEA is developed by the Central Planning Agency (CPB): an independent research institute working among others at the government's request. Due to the (unanticipated) elections, the CPB was occupied by calculating effects of the election programs and unavailable for their work on the Afsluitdijk.

protection only and expected other parties to further develop the components. The components lagged significantly behind in terms of organisation, plan development and allocating budget. In addition, the ministry stated that flood protection will not be delayed by the components. As a consequence, the PDA entailed a flood protection core only: the overflow-resistant dam. Disappointment with the course of the project resulted in a period of minimal interaction between the flood protection trajectory (led by the ministry) and the trajectory of developing components (led by other parties). Relationships improved only when an administrative agreement was signed, through which the ministry and governmental parties representing components agreed upon conditions for possible future combination of the core and various components.

In the following sections the interaction among a flood protection KA and a nature KA will be elaborated upon.

4.1. Phase 1: design

The design phase was set up in an integrated way, involving a broad range of actors. The project team consisted of representatives of the ministry as well as two provincial representatives. Over 200 people participated in workshops to make an inventory of possible ideas for the Afsluitdijk. Market parties were invited to develop visions as that was believed to result in the most innovative designs. The ministry formulated the assignment to do more than flood protection alone, while the provinces were interested in an integral approach which combined multiple functions. This phase was characterised by a stimulating creativity in the development of ideas. The ministry made financial reservations for the realisation of the Future Afsluitdijk.

The project had an integral character, but the embedding of this integration was weak. In particular, 'other functions' (not flood protection) were only marginally organised. For instance, there was no formal agreement between the province and the ministry in the project team. There was no further detailing as to what 'more than flood protection alone' or the nature function entailed (as opposed to the detailed description of the flood protection objectives), nor was there a prioritisation of additional functions. Nature and other functions were open for discussion and left to the creativity of the market parties. Moreover, the follow-up process – after the completion of the visions – was undefined and remained vague until the spring of 2009. Integration was also not reflected by the available resources, only the ministry had resources allocated for the project.

Two different knowledge bases were developed in the design phase. First, market parties developed integral visions, inspired by the workshop outcomes. The visions were developed under a strict time schedule imposed by the project team. As a result an entire design cycle was not possible and the visions lacked in-depth discussions and a thorough knowledge base underpinning the designs. The relative open assignment led to major diversity of visions (see Appendix 1). As the market exploration had characteristics of a competition setting,[6] the market parties strived for a distinctive eye-catching design, rather than the most sensible plan.[7] A second knowledge base was developed by the ministry. Two 'governmental reference designs' were designed to be compared with the integral designs.

In the design phase, there was no full nature KA, but there was one germinating. Actors in the nature domain were incidentally involved in the project: they participated in idea development workshops and provided reflections on integral visions. But nature protection actors were not organised and had no clear ideas for the future of the Afsluitdijk.

An overview of the interacting KAs in this design phase is provided in Fig. 4.

4.2. Phase 2: assessment

The integral set-up of the project, formed at the start of the project, was still in place during the assessment phase: the ministry and provinces were in one project team and there was a shared discourse and shared ideas about the rules of the game. However, after preparing the visions, the market parties played no role anymore. Instead of 'idea development' the discourse changed to a focus on 'the feasibility of cores and components'. Each core and component was assessed on financial, technical and maintenance feasibility. Also in this phase the ministry secured financial reservations, although the availability of the budget became more uncertain due to the economic crisis and the political crisis of the coalition government. The rules of the game included an environmental impact assessment (EIA), a cost effectiveness analysis (CEA) and an assessment framework for supporting final decision-making. This all directly related to the development of knowledge.

The assessment of cores and components led to an extensive knowledge base over a period of about two years (Appendix 2). The knowledge base related to separate cores, components or aspects. This approach resulted in the fragmented development of knowledge as knowledge was produced in separate reviews, research reports and expert sessions. Reviews and assessment were provided on flood protection, nature protection and ecology, spatial quality, sustainable energy and maintenance; expert sessions were held on nature protection and sustainability; and research reports were produced on morphology of sand nourishment, on feasibility of the storm shield, and on legal feasibility of the designs. Depending on the topic, different scientific institutes, different experts, different governmental agencies and/or different interest groups were involved.

The nature KA strengthened in this phase through involvement of nature protection organisations in stakeholder meetings and the expert session on nature. In general, though, nature protection organisations were dissatisfied and disappointed by the course of the project. According to a nature protection respondent: "nature protection organisations were disappointed because at the end of 2010 the project ambition on nature turned out to be of little substance". Furthermore, concern existed regarding the negative attitude of the national government towards nature and the limited availability of financial resources for the project. Nature protection organisations organised and set up a design exercise themselves in order to collect possible ideas related to nature protection or development and an integral approach. Their effort resulted in the publication Afsluitdijk Naturally Safe[8] (Stichting VBIJ and Waddenvereniging, 2010). The financial resources in the nature KA were minimal. The Future Afsluitdijk project team was hardly aware of the activities in the nature KA. An overview of the interacting KAs in this assessment phase is provided in Fig. 5.

4.3. Phase 3: decision-making

When the feasible cores and components were determined, three cores remained (a traditional height increase, the overflow-resistant dam and the storm shield) and six components (pilots for sustainable energy, a sustainability centre, pilots for silt

[6] In the perception of market parties, the design assignment was a competition, although it was explicitly stated by the project team that this was not the case.

[7] Interview respondent market party.

[8] In Dutch: Afsluitdijk Natuurlijk Veilig.

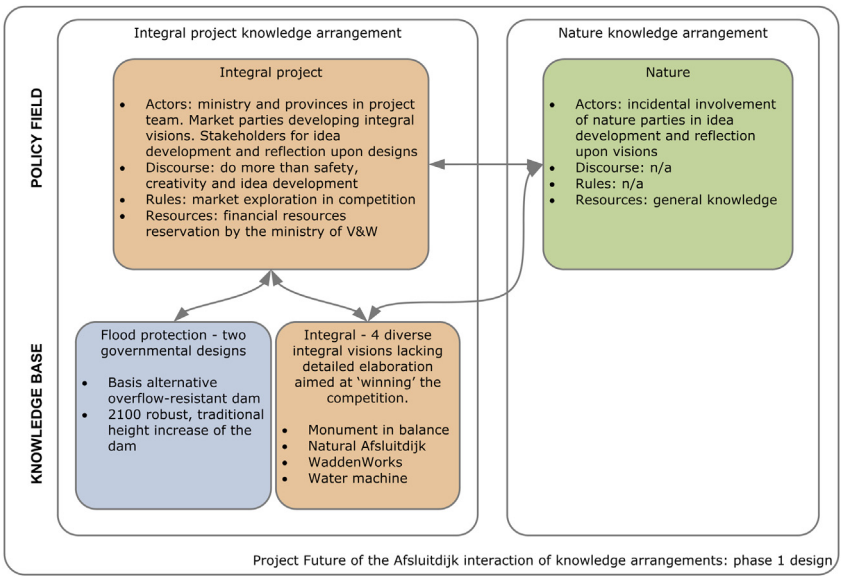


Fig. 4. Overview of interacting knowledge arrangements in the design phase of the Future Afsluitdijk project.

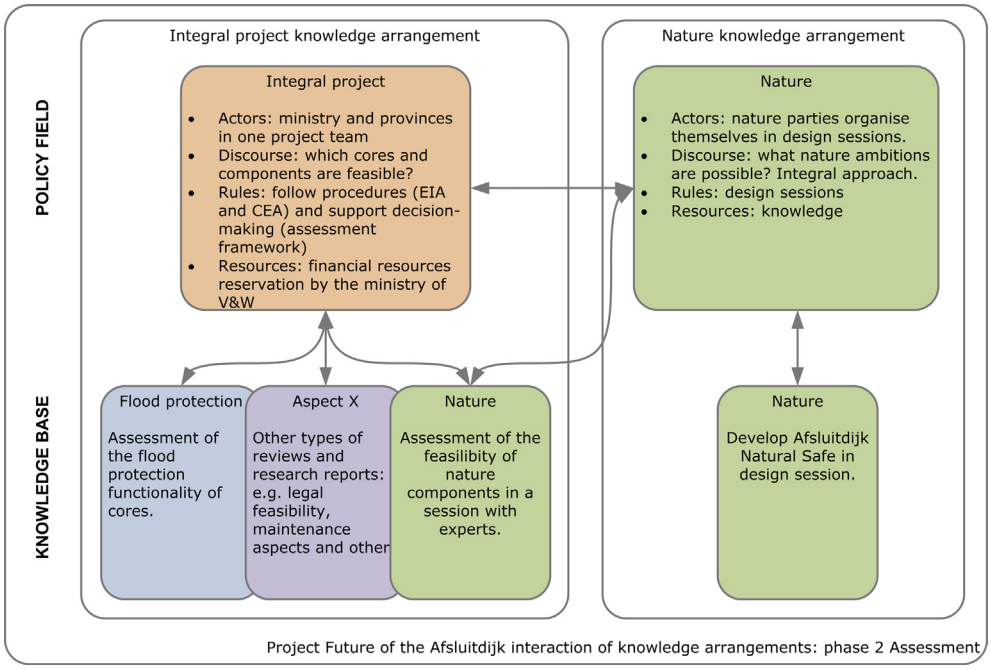


Fig. 5. Overview of interacting knowledge arrangements in the assessment phase of the Future Afsluitdijk project.

agriculture, fresh-salt transition, small-scale recreation and naviducts). These cores and components were considered for further decision-making in order to establish a preferred design alternative (PDA). The project KA changed significantly at this point, by turning from an 'integral' to a 'flood protection' KA. The collective project team, consisting of the ministry and provinces, was replaced by another platform, excluding the provinces. The ministry changed their discourse into one emphasizing primary responsibility for flood protection, and no prior responsibility for nature protection or development. Financial resources were attributed to flood protection. The development of the PDA directly affected the development of knowledge. It required selection among the three cores and development of plans for components.

In the assessment phase the nature parties organised themselves, but only in this decision-making phase they were explicitly challenged by the project team to develop a substantial plan for nature: the fresh-salt transition in the Afsluitdijk. This plan however could not be included in the PDA, as it was not sufficiently complete. But the joint responsibility for its development further strengthened the nature KA, in terms of organisation building (a nature coalition was formed guided by the program 'Towards a rich Wadden Sea[9]' and in the Afsluitdijk Ambition Agenda coordinated by the provinces) and in terms of developing a plan for fresh-salt

[9] In Dutch: Programma Naar een Rijke Waddenzee.

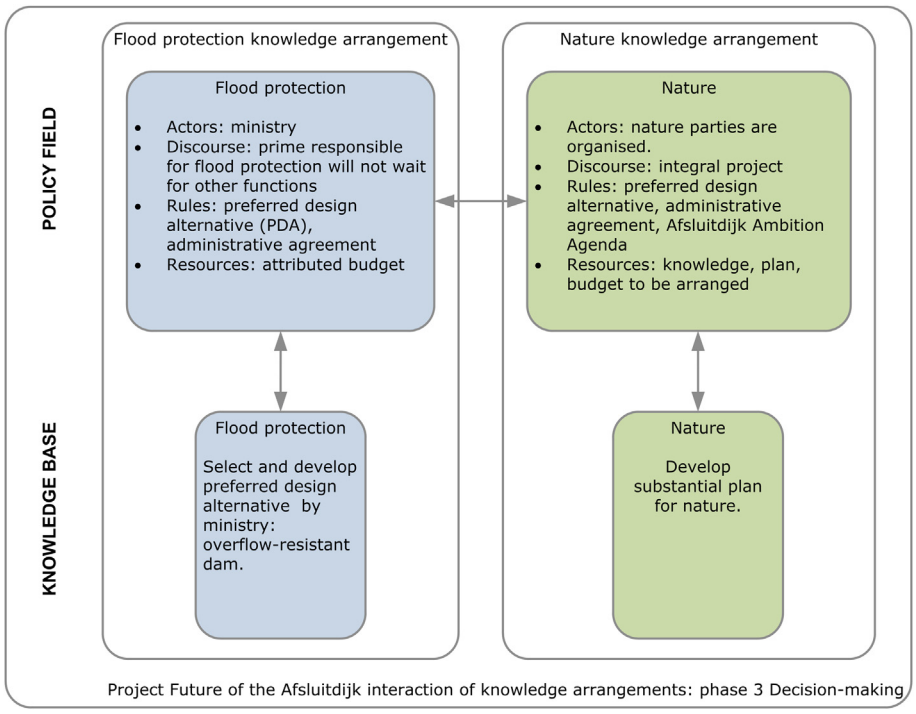


Fig. 6. Interacting knowledge arrangements in the decision-making phase of the Future Afsluitdijk project.

water transition. Building upon Afsluitdijk Naturally Safe (Stichting VBIJ and Waddenvereniging, 2010), the ideas for a fresh-salt transition matured into the idea of a 'fish migration river'. After 2011, some first financial resources were made available for developing the fish migration river.

The administrative agreement was signed in December 2011 and formulated conditions and requirements for future involvement of the components, among others the nature plan, into the flood protection project. An overview of the interacting KAs in this decision-making phase is provided in Fig. 6.

5. Discussion

As hypothesised in Section 2, greening flood protection depends on the integration of KAs. What has the case study on Future Afsluitdijk taught us in this respect?

In the project Future Afsluitdijk the type and degree of interaction between KAs changed over time. In chronological order, the process touched upon three ideal types of interaction (Section 2.2.): integration, separation and cooperation. Fig. 7 schematically relates the three interaction forms to the different phases in the project.

5.1. Failure of the integrated knowledge arrangement

In the design phase and the assessment phase an integrated project KA could be identified in which the domains of nature and flood protection were integrated. In particular in the design phase, the integrated arrangement covered both functions. Yet, this integrated KA failed towards the end of the assessment phase when nature interest groups started to organise themselves along separate lines and processes. The project proved not as integrated as it had seemed at first sight.

The integrated KA was not sufficiently institutionalised in the project. Three factors can explain this lack of institutionalisation: (1) the integration at the level of policy fields, (2) the large distance between the project and the development of the integral visions by market parties, and (3) the abandonment of integration in assessing alternatives.

Looking at the four dimensions of policy fields, integration at policy field level lacked structural embedding. Cooperation among policy actors from different fields remained without further obligations. Financial resources for the project were not shared, but were reserved by the ministry only. The discourse seemed of an integrated nature and was shared among the different participants, but was uneven in content: the flood protection function was defined in detail, while the nature function remained rather unspecified, open for discussion and left to the creativity of the market parties. The general formulation of nature or ecological objectives for GFP is more often noticed (Janssen et al., 2014; Knol, 2013). The design phase witnessed shared rules of the game, however the process to proceed after the design was undefined and unknown. In retrospect and despite ambitions of the project, the integration of the policy fields of nature and flood protection in the design phase was built upon quicksand. It either required reinforcement or, as happened, was bound to fall apart.

Lack of institutionalisation of the integrated KA is also due to the large 'distance' between the integral project policy field and the development of the integral visions by the market parties. The 'distance' between the integral project organisation and the governmental reference designs was notably smaller. Three factors explain the difference in 'distance'. First, ministerial representatives (who were part of the project team) developed the governmental reference designs, while the integral visions were developed by external market parties. The project team deliberately remained at distance from the integral visions of the market parties in order to be able to judge more objectively. When actors are involved in knowledge development they are more likely to accept the outcome (Eshuis and Stuiver, 2005; Hommes et al., 2009). Second, the knowledge base in the development of the integral visions did not match the knowledge base within the policy field. The WaddenWorks integral vision (see Appendix 1) was illustrative for this mismatch. This vision was based on 'soft',

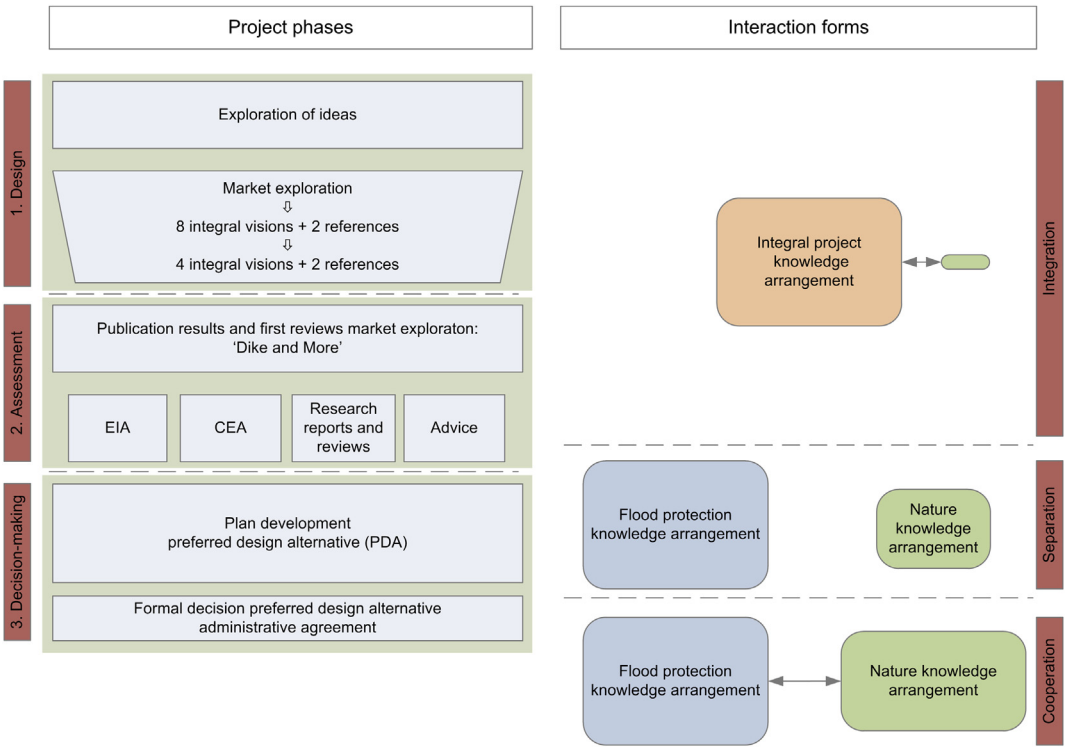


Fig. 7. Three forms of interaction among knowledge arrangements in the project Future Afsluitdijk: integration, separation and cooperation.

building-with-nature type of physical processes of sand and sediment transport, but applications of and experiences with these types of physical processes are limited in this region. A respondent of the market parties reflected on the knowledge background within the ministry: "There is a technical idiom, which they are very good at. The physical processes relevant for dunes and the functioning of dunes in flood protection are not their expertise." Hard constructions for flood protection prevail in this area. Based on the known practices and their epistemologies actors interpret and value different knowledge in different ways (Hommes et al., 2009). Third, the transfer of knowledge to the policy actors and fields has been limited. Integral visions of the market parties – captured in reports – were send to the project team with only limited verbal explanation. According to a respondent of one of the market parties, transfer of the underlying ideas of each of the visions "never really happened". Transfer of knowledge is not only about objective information, but includes subjective views and values. In a situation where experts have diverging background this can be very challenging (Vinke-De Kruijf et al., 2013). Face-to-face communication is highly relevant in order to transfer this tacit knowledge (Koskinen et al., 2003) as well as intensive interaction (Vinke-De Kruijf et al., 2013). Interpreters or knowledge brokers can play a critical role in translating the integral designs into a policy field (Holmes and Clark, 2008; Naylor et al., 2012). Due to the large distance and hence poor embedding of the integral visions in the policy field, ownership of the designs by policy actors failed, in contrast to ownership of the governmental reference designs. The lack of knowledge uptake suggests a re-organisation of the relation between knowledge developers and decision-makers towards an intensified cooperation and exchange of ideas (De Jonge, 2007).

The last explanation of a lack of institutionalisation of the integrated KA relates to the assessment process. During the assessment phase the policy field was still to a significant extent integrated, but the knowledge base lacked integration: the integrated visions were split up and cores and components were judged independently. Also separate aspects were reviewed rather than the multiplicity of functions. According to one of the project members: "the project team did not manage to find an appropriate method that brings about synergy and leads to an integrated assessment". Splitting the integrated visions into cores and components was not self-evident: fierce project discussions preceded this decision. On the one hand 'cherry-picking' was considered unfair, but on the other hand the highly diverse visions were considered incomparable. The developers of the cost effectiveness analysis were decisive with their request to split the visions to enable a 'sound comparison'. Integrated designs require an assessment approach that equally values the interdisciplinary nature. But while this is acknowledged, methods to do so remain largely sectoral oriented (De Jonge et al., 2012). The development of integrated approaches is highly challenging given the complex and nonlinear social, ecological and economic relations, while for decision making straightforward answers are desired (De Jonge et al., 2012). Moreover, information and data is constrained by spatial and temporal boundaries (Knol, 2013).

In the case study, assessing separate aspects rather than integrated visions was not without consequences. It led to the conclusion that cores and components were independent and lacked synergy. Moreover integrated assessment is important for optimisation of multiple functions in concert, rather than separate functions. But optimisations and design improvements were off the agenda in the assessment phase. The integral visions were treated as fully developed design alternatives while according to a market party representative: "the designs got the status of solutions, while these were developed in a very short period". When a change in design was proposed a ministerial representative stated that: "it does not fit the process to change the […] design".

5.2. A period of separation and self-organisation

An interaction form of 'separation' emerged in November 2010 when nature parties organised themselves and the flood protection domain raised access barriers by formulating strict access-criteria: plans should be sufficiently substantial in terms of organisation, content and finances. A number of developments in the project preceded this new situation. Nature parties were dissatisfied with the poor representation of nature in the project, the ministerial financial resources turned out to be minimal and flood protection was given prominence and priority. The ministry focused on its core task of safeguarding flood protection and explicitly allocated responsibility for nature to the program 'Towards a rich Wadden Sea'. Moreover, the ministry made realising the flood protection standard independent from the development of nature plans. As a consequence, two separate KAs emerged: a flood protection KA and a nature KA. Mutual disappointment, different perspectives and discourses, and an inward focus on developing plans within domains severely reduced the interaction between the two arrangements. The difference between the two arrangements is illustrated by a discussion on the criteria for substantial plans. A provincial respondent indicated: "for the ministry something is not substantial when no money is reserved. For the province substantiality is about development trajectories, pilots and experiments, and the big money will come later". In contrast, a ministerial respondent argued: "substantial plans and financing are required. The region [i.e. parties concerned with other functionalities such as nature] remains too vague". Interaction became problematic in this phase, as a ministerial respondent noted: "it is difficult to have contact with the province." During this period of separation, developments were mainly taking place within domains and not across domains.

Separation between KAs and an internal focus within each domain characterised this phase. The resulting strengthening of the nature domain is interesting. While at the start of the project the nature domain was almost non-existent – nature parties were not organised, only incidentally involved and had neither resources nor specific plans for the Afsluitdijk – the explicit criteria raised by the flood protection domain caused the nature domain to organise themselves in terms of actor coalition, discourse and knowledge.

5.3. Cooperation as second best

The period of separation was followed by a period in which cooperation arose between the domains. Tuning developments in each of the domains was established. Important in this respect was the ambition agreement that was signed by the ministry and regional governmental authorities representing functions such as nature. In this agreement, requirements for nature functions to become part of flood protection were specified. These requirements were: sufficient financial resources, technical or procedural dependency with the flood protection project, and no delay for the flood protection project. In that sense, flood protection remained the dominant domain, and determined the conditions. But these conditions became aligned with and agreed upon by the nature domain. Cooperation was established between the domains, yet integration vanished out of sight. Separate trajectories do not foster integrated or collective developments, as acknowledged by one of the project participants: "if you don't work together towards a solution, coherence diminishes" (ministerial respondent). GFP is not established, yet realisation of two separate functions is.

6. Conclusions

In this paper we aimed to understand the role of knowledge in greening flood protection (GFP) projects by specifically looking at the interaction between knowledge-policy fields, defined as knowledge arrangements (KA).

Knowledge for GFP is essentially different from sectoral or mono-disciplinary knowledge development as it requires overcoming differences across domains. The Afsluitdijk project is an illustrative example of the struggle to organise a knowledge process towards an integrated, GFP design. When we consider the ambition of the project –an innovative, creative and integral design – the result can be considered disappointingly poor as it did not lead to a multifunctional design. Could this have been different? A reflection of one of the project members is appropriate here:

> "a question that continues to rankle is whether we looked enough for synergy. The integral visions were to some extend comprehensive, but these were only 'ideas', without involvement of stakeholders. You cannot prove that synergy would have come about when this was headed for from the beginning. I also don't know".

The break between the two domains did not have one single cause. Of course the financial resources turned out minimal and available for flood protection only, but at that point the nature organisations were already dissatisfied and had started separate plan development. The separate assessment of cores and components did not have an integral focus and led to the conclusion that there was no synergy. Moreover, the ministry stated that flood protection would be developed independent from other plans. The strict terms for the nature plans proved to be a blessing. It forced the nature domain to further organise itself in terms of content, actor coalitions and resources.

Based on the analyses lessons can be drawn on the implementation of GFP and the role of knowledge herein. Lessons learned from this project are important for any future project aiming at a multidisciplinary approach and are relevant for those with the ambition to implement GFP in practice, whether that are decision-makers, stakeholders or knowledge developers. GFP requires integration among knowledge arrangements, which is improved by:

- Organizing knowledge at close distance to the policy process: include a broad range of stakeholders in knowledge development with intensive interaction. This improves ownership and uptake of the knowledge developed.
- Including multiple design iterations in the knowledge process as it allows for optimising designs.
- Structurally embedding integration at the policy level: by agreements among stakeholders and detailing ambitions for other functions. Commitment in terms of financial resources may help.
- Tools to assess integrated designs in an integrated way, instead of a focus on separate aspects.

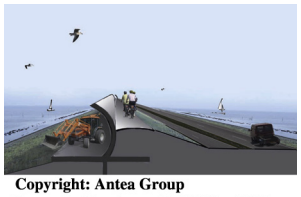
In the scientific literature the role of knowledge in projects has been subject to extensive studies (McNie, 2007; Seijger et al., 2013). We add to this body of knowledge a focus on interaction among different 'knowledge arrangements', emphasizing the context related character of knowledge and the idea that multiple policy fields are around. From this we learn that integration at the level of policy fields is an important factor for the uptake and development of knowledge.

Acknowledgements

The authors thank the participants of the project Future Afsluitdijk for their open and welcome attitude and their cooperation in this research, the respondents for their cooperation in interviewing, and the foundation Ecoshape for the financial support of the research project. We also like to thank four reviewers for their valuable and useful comments and suggestions.

Appendix 1. Overview of integral visions and reference designs

Table 1
Summary of the four integral visions and two governmental reference designs, highlighting the main elements (source: Rijkswaterstaat et al., 2009)

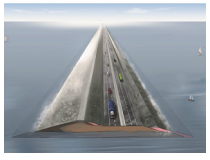


Monument in balance (in Dutch: *Monument in Balans*)
The flood protection level of the dam is reinforced by means of a 'storm shield'. Spatial developments are located at the ends of the dam. Space is created for a sustainability centre and an innovation island. The vision includes a 'fresh-salt passage' and replacement of bridges and sluices by means of a naviduct.

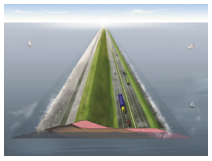
Natural Afsluitdijk (in Dutch: *Natuurlijk Afsluitdijk*)
This vision combines nature development and energy production south of the Afsluitdijk. It includes a 'blue energy' power station (energy from using the difference in potential of fresh and salt water) and power storage by means of a 'fall-lake'. Flood protection is achieved by means of a traditional increase of the dam. A second 'nature dam' is located south of the Afsluitdijk. The vision includes a sustainability centre and a naviduct.

Wadden Works (in Dutch: *Waddenwerken*)
WaddenWorks reinforces the Afsluitdijk by means of sand nourishment at the Wadden Sea side of the dam. Areas of salt marshes emerge improving the natural value. A 'fresh-salt passage' is created in the Wadden Sea. This vision foresees a blue energy power station and bridges to improve mobility.

Water machine (in Dutch: *Watermachine*)
Flood protection is improved by means of an 'overflow resistant' dam (*in Dutch: overslagbestendige dijk).* An 'in-between' lake is created, with a nature dam and a gradual fresh-salt transition. Furthermore, the vision includes a power station using tidal energy, small scale recreation, salt-water agriculture and a naviduct.



Governmental reference design: Basis alternative overflow-resistant dam
The covering of the entire dam surface is reinforced and made overflow resistant. In the exceptional case of overflow, the salt water will not damage the dam. The inside slope of the dam is faded. A new bicycle track is developed on the 5 m additional width.



Governmental reference design: 2100 Robust traditional dam increase
In this design the dam is heightened 2.5 m and broadened 30 m.

Appendix 2. Project documents Future Afsluitdijk

Below three tables list the main project documents, reviews, advices, research reports, expert sessions and integral visions in the three phases analysed in the project Future Afsluitdijk supporting Fig. 3. This list does not cover each report, memo, and documents produced as we have limited ourselves to listing the main ones. The documents are in Dutch.

Table 2
Overview of the main project documents, advices, and integral visions in the design phase of the project Future Afsluitdijk

Type	Title	Author	Date
Project document	Toekomst Afsluitdijk, resultaten van een participatieve verkenning	Instituut SMO	Mar-08
Project document	Toekomst Afsluitdijk Acht integrale visies, resultaten van een marktverkenning (fase 1)	Rijkswaterstaat, provincie Fryslân provincie Noord- Holland	Aug-08
Advice	Beoordelingsadvies Adviescommissie Afsluitdijk	Adviescommissie Afsluitdijk	Aug-08
Advice	Review rapportage fase 1 in het kader van de marktverkenning Afsluitdijk	Innovatieplatform	Sep-08
Advice	Onderzoek integrale verbetering Afsluitdijk	College van Rijksadviseurs	Sep-08
Integral vision	Waddenwerken, een veilige kering die meegroeit met de zee	DHV B.V., IMARES, Bureau Alle Hosper	Nov-08
Advice	Vervolgproces Afsluitdijk: Advies Adviescommissie	Adviescommissie Afsluitdijk	Nov-08
Integral vision	Monument in Balans - Integrale visie op de Afsluitdijk	CE Delft, GDArchitecten, NoordPeil landschap&stedenbouw, Ingenieursbureau Oranjewoud B.V.	Dec-08
Integral vision	Afsluitdijk 21e eeuw, Voltooiing Zuiderzeewerken: van dam naar watermachine	ARCADIS, Dredging International, Nuon insamenwerking met H + N + S landschapsarchitecten	Dec-08
Integral vision	Natuurlijk Afsluitdijk	Royal Haskoning, Wubbo Ockels, BAM, Eneco, Lievense, Rabobank, Van Oord	Dec-08
Project document	Toekomst Afsluitdijk Vier visies, resultaten van een marktverkenning (fase 2)	Rijkswaterstaat, provincie Fryslân provincie Noord- Holland	Dec-08

Table 3
Overview of the main reviews, project documents, research reports, advices, and expert sessions in the assessment phase of the project Future Afsluitdijk

Type	Title	Author	Date
Review	Reactie op uitwerking vier consortia in tweede fase Marktverkenning Afsluitdijk – review cultuur	Rijksdienst voor archeologie, cultuurlandschap en monumenten	Jan-09
Review	Technische haalbaarheid. Review rapportages fase 2 in het kader van de marktverkenning	TU Delft	Jan-09
Review	Advies over eindrapportages marktverkenning Afsluitdijk – review innovatie	Innovatieplatform	Feb-09
Review	Evaluatie marktverkenning	Rijksuniversiteit Groningen, Netwerk Deltatechnologie	Feb-09
Project document	Dijk en Meer; Eindrapportage verkenning Toekomst Afsluitdijk	Rijkswaterstaat, provincie Noord- Holland, provincie Fryslân	Mar-09
Review	Duurzame energieopties bij integrale verbetering van de Afsluitdijk – review duurzame energie	ECN	Mar-09
Review	Toekomstperspectieven Afsluitdijk – review natuur ecologie	Dienst landelijk gebied	Mar-09
Review	Review vier visies Afsluitdijk – review ruimtelijk	College van Rijksadviseurs	Mar-09
Research report	Agenda voor de Afsluitdijk Een maatschappelijke vergelijking van vier visies voor de toekomst van de Afsluitdijk (kengetallenkosten-batenanalyse KKBA)	Decisio in cooperation with Tauw	Mar-09
Project document	Kostenvergelijk ramingen visies en overheidsalternatieven	Project team Toekomst Afsluitdijk	Mar-09
Review	Beheerderadvies Rijkswaterstaat Ijsselmeergebied bij de vier visies voorgekomen uit marktverkenning “Onderzoek Integrale Verbetering Afsluitdijk” – review beheer onderhoud	Rijkswaterstaat Ijsselmeergebied	Mar-09
Advice	Eindadvies adviescommissie verkenning Toekomst Afsluitdijk	Adviescommissie Afsluitdijk	Mar-09
Review	Review ‘Waddenwerken’ – Morfologie	TU Delft	Mar-10
Expert session	Expertsessie natuur	Project team	Mar-10
Expert session	Expertsessie Duurzaamheid	Project team	Apr-10
Research report	Verkenning zilte landbouw Mogelijkheden van zilte landbouw en aqua-cultuur binnen de vier visies van het Afsluitdijkproject	Grontmij	Apr-10
Research report	Karakteristieken van duurzame energie in relatie tot de Afsluitdijk; Kostendata en andere parameters voor de evaluatie van duurzame energieopties in verband met integrale verbetering van de Afsluitdijk	ECN	May-10
Research report	MKBA Afsluitdijk - Uitwerking van de “ambitiecomponenten” concept	Decisio	May-10
Project document	Ingevuld Afweegkader Toekomst Afsluitdijk “Kernen en componenten langs de meetlat”	Project team Toekomst Afsluitdijk	May-10
Review	Review Afsluitdijk: Stormschild	TU Delft	Oct-10
Advice	Briefadvies Afsluitdijk vanuit Waddenperspectief	Raad voor de Wadden	Oct-10

Table 3 (*continued*)

Type	Title	Author	Date
Advice	Advies MER Afsluitdijk	College van Rijksadviseurs	Oct-10
Advice	Gezamelijk advies stakeholders	Stakeholders	Nov-10
Advice	Advies van de Adviescommissie Toekomst Afsluitdijk	Adviescommissie Toekomst Afsluitdijk	Nov-10
New ideas	Schetsboek Afsluitdijk	Waddenvereniging	Nov-10
Advice	Visie op DE Afsluitdijk	Energy Valley	Nov-10
EIA	Plan-MER Toekomst Afsluitdijk (Environmental Impact Assessment, EIA)	Grontmij	Dec-10
Research report	Natuurwaardenindicator Toekomstvisie Afsluitdijk. MKBA van huidige en te verwachten natuur in de Waddenzee en IJsselmeer als gevolg van het project Afsluitdijk	Grontmij	Dec-10
Research report	Risicobeoordeling Natura 2000 Toekomst Afsluitdijk	Grontmij	Dec-10
CEA	Een kosten-effectiviteitsanalyse naar de toekomstige inrichting van de Afsluitdijk (Cost Effectiveness Analysis, CEA)	Centraal Planbureau	Jun-11

Table 4
Overview of the main project documents and advices in the decision-making phase of the project Future Afsluitdijk

Type	Title	Author	Date
Advice	Afsluitdijk – Advies Commissie van Deskundigen	Commissie van Deskundigen - Afsluitdijk	May-11
Advice	Adviescommissie Toekomst Afsluitdijk Eindadvies	Adviescommissie Toekomst Afsluitdijk	Jun-11
CEA	Een kosteneffectiviteitsanalyse naar de toekomstige inrichting van de Afsluitdijk	Centraal Planbureau	Jun-11
EIA	Plan-MER Toekomst Afsluitdijk	Grontmij	Jun-11
Advice	De Afsluitdijk	College van Rijksadviseurs	Jun-11
Project document	Ontwerp Structuurvisie Toekomst Afsluitdijk	Ministerie van Infrastructuur en Milieu	Jun-11
	Ambitie Agenda Afsluitdijk, triple A	Provincie Noord-Holland, Provincie Fryslân, Gemeente Wieringen, Gemeente Súdwest-Fryslân, Gemeente Harlingen	Dec-11
Project document	Bestuursovereenkomst Toekomst Afsluitdijk	Ministerie van Infrastructuur en Milieu, Provincie Fryslân, Provincie Noord-Holland, Gemeente Súdwest-Fryslân, Gemeente Wieringen	Dec-11

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