Adaptive planning for flood resilient areas: dealing with complexity in decision-making about multilayered flood risk management

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Abstract
This paper aims to provide insight into how to cope with complexity and uncertainty in decision making on flood resilience in 13 pilot areas in five countries. This study is part of the Interreg North Sea region project FRAMES. In the pilots different actors work on the exploration and implementation of diversified strategies for flood resilience, based on multiple elements of the disaster management cycle. To gain understanding of the complexity these actors are facing, we discuss more generic insights in climate change adaptation and the complexity of joint action. Since the decisions to be made in the pilot regions depend on the uncertainties about the future, we investigate the supporting role of backcasting and Dynamic Adaptation Policy Pathways in making robust decisions in our present volatile world. Against this backdrop the current flood risk governance arrangements of the participating countries are compared by employing and extending the analysis of the STARFLOOD project (Matczak et al., 2016). These countries differ in their approach towards flood resilience, involving different types of decisions to be made. This variety reflects their historical coevolution with country specific governance settings. In this paper we present our preliminary findings of the transnational learning process within the FRAMES project. In two workshops we have discussed the challenges and complexities considering adaptive strategies for flood resilience. Furthermore we will reflect on the preliminary results of the learning process, flood risk governance arrangements and the presented theoretical background. We will conclude that adaptive planning can support regions in dealing with the complexity and uncertainty in the decision-making and strategy development for flood resilience. Elements of both backcasting and DAPP can complement each other in a co-evolutionary planning approach for flood resilience.

1. Introduction

In the face of climate change, a major challenge for decision makers in flood risk and disaster management is to make robust decisions on flood management options. The ability of decision makers, especially flood risk managers to make such decisions is vital in reducing the socioeconomic and physical (infrastructure) impact of flood disasters. This requires an adequate understanding of the best flood management options available. However, decision making on these options are typically surrounded by large uncertainty and complexity due to the volatilities of the present climate change with intensified and unpredictable extremes (Boelens et al. 2017). This may complicate articulating long-term policy ambitions on flood resilience as well as the development of strategies for realizing these ambitions (Bormann et al., 2015).

In dealing with uncertainty and complexity in decision making, strategic planning instruments like backcasting and Dynamic Adaptation Policy Pathways (DAPP) can support the decision making process of selecting flood management options and bridging gaps in our understanding of uncertainties and available flood management options. It is assumed these instruments can support flood risk managers in engaging the community. Such instruments provide a transparent means to justify a decision made. This would improve a flood risk manager's ability to make informed decisions and the community's resilience to flood disasters in a specific region. Based on self-organization, planning for the future should deal with uncertainties and be an ongoing and adaptive process (Boonstra 2015, Morçöl, 2012:112). Adaptive planning processes like Dynamic Adaptation Policy Pathways affect the development of climate adaptation strategies and how they deal with uncertainties (Haasnoot et al., 2013; Tempels, 2016; Bloemen et al., 2017). Adaptive planning techniques can be applied to discuss future uncertainties with other stakeholders. Local information needs to be included in these discussions (Bloemen et al., 2017).

The FRAMES project (Interreg North Sea Region) addresses a shared territorial challenge, where on-going climate change leads to increasing sea levels and extreme rainfall patterns for areas and communities in the North Sea Region. As the physical, economic and social effects of floods are likely to further increase, traditional flood prevention measures (physical infrastructure) become more expensive and may not be sustainable in the future. Flood protection for every single citizen would be too expensive, but a smart combination of resilience measures could minimize impact in a cost efficient way. The development and implementation of such measures requires collaborative effort as no single organization or actor has the knowledge and/or capacity to develop sustainable solutions for these challenges alone.

FRAMES includes 13 pilot areas in five countries in the North Sea Region (Belgium, Denmark, Germany, The Netherlands and United Kingdom), which are developing more diversified strategies to increase flood resilience, based on multiple elements of the disaster management cycle. We refer to these strategies as multi-layered approaches. In each of these pilots various actors work on the exploration and implementation of measures to limit the consequences of different types of flooding and to enhance opportunities for recovery.

In this paper we apply a co-evolutionary approach to develop applied knowledge about strategies for flood resilience. At one hand we explore the relevant theoretical frameworks about complexity, governance and adaptive planning, and at the other we facilitate a learning process with and among the pilots to discuss the complexity and (future) decisions to be made for flood resilience strategies in their region.

Due to the historical coevolution of flood risk management approaches and country specific governance settings (e.g., institutions, finance, responsibilities, and politics), these areas face different points of departure and options for dealing with complexity and uncertainty in decision making on flood resilience. Therefore, the paper aims to provide insight into how to cope with complexity and uncertainty in decision making on a multilayered approach of flood resilience. The paper focuses on the supporting role of strategic planning instruments like backcasting and Dynamic Adaptation Policy Pathways (DAPP) in making robust decisions under deep uncertainty.

To compare the country specific governance setting, we employ a framework developed by Hegger et al. (2014) to analyze flood risk governance arrangements in the pilot regions. The framework is here applied to compare the pilot regions of our study (Section 3). As argued by Termeer et al. (2011) and Bormann et al. (2015), there is a prime role for regions in the challenge of climate adaptation. This is contrary to climate mitigation in which the global and national level are in the lead (Termeer et al., 2011). We consider the pilots in FRAMES as regional explorations for climate adaptation with a focus on flood risk management. These pilots align with the recommendations by Van Buuren et al. (2015) to conduct pilots for multilayered safety strategies and shape these as regional processes of joint searching and learning for the societal challenge of flood risk management.

These pilots provide further insight into the different points of departures for decision makers in developing multilayered strategies for flood resilience, but also how strategic planning approaches could support them in doing so. In this paper we explore the possibilities for a decision support system (DSS) that help decision makers in developing robust strategies for flood resilience.

The paper is structured as follows: Section 2 presents theoretical perspectives on complex decision making under uncertainty. Section 3 briefly describes the framework for comparison and compares the current flood risk governance arrangements in pilot areas. Section 4 presents decision-making and adaptive planning in multi-layered safety pilots, based on workshops with the pilots managers. In Section 5 we discuss the preliminary results of this study and reflect on added value of adaptive planning approaches to support decision-making about multi-layered flood risk management approaches.

2. Theoretical perspectives

In the challenge of flood resilience, decision makers need to deal with complex interdependencies between social and ecological systems (Pahl-Wostl et al., 2007; Tempels, 2016). On the one hand, they need to continue with deliberate planning interventions (related to an ongoing desire for control and the striving to come to power), but on the other hand, they also need to take self-organised processes into account (Boelens, 2009; Teisman & Edelenbos, 2011; Boelens & De Roo, 2016). This intrinsic complexity of governance poses considerable uncertainty in both our understanding of and dealing with wicked problems like flood risk management and climate change adaptation. In section 2.1 we point out several characteristics of the complexity of climate adaptation and the complexity of climate adaptation governance processes. In section 2.2 we introduce backcasting and Dynamic Adaptation Policy Pathways (DAPP) as strategic planning instruments for dealing with uncertainty and complexity in decision making. In chapter 3 we will introduce the pilots in our study and the current flood risk governance arrangements in which they operate.

2.1. Complexity and uncertainty of climate adaptation governance

2.1.1 Complexity of climate adaptation

As addressed in the introduction we present relevant theoretical perspectives on the governance of climate change adaptation, which can be considered as deliberate planning and self-organized processes. In the realm of climate change there is a need for deliberate planning, since we are aware of potential climate change effects and associated risks for society. Adaptation by society to the impact of climate change is defined as: *"adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities"* (IPPC, 2007, see Termeer et al., 2011: 159).

Van Buuren et al. (2013) distinguish several characteristics that contribute to the complexity of adaptation to climate change.

- **Uncertainty.** At the moment of decision-making it is often not known whether adaptation is necessary, whether the proposed measures are enough and whether they generate the intended results (see also Bormann et al., 2015). This can result in hesitation and delay in decision-making, building in margins and additionally safety measures, a need for no- and low-regret measures, and possibilities to reconsider decisions when the situation and/or scenarios change.
- **Contentiousness**. Climate change has an inherent controversial character, which also hampers agreement in decision-making about climate adaptation measures. Different viewpoints on the seriousness and urgency of climate change and its consequences emphasize the normative character of climate change adaptation.
- **Multiplicity.** Consequences of climate change are heterogeneous. Local and regional effects of macro-level patterns like sea-level rise and global warming can be very different in another geographical context. Farmers in one area could for example benefit from temperature rise, while others suffer. It is the challenge to develop (multifunctional) adaptation strategies with a clear win-win character, for example by storing water for dry periods.
- **Non-linear and erratic nature.** Climate change is characterized by non-linear feedback loops, which can result in a capricious processes and surprising effects. This links to the concept of complex adaptive systems used in the socioecological literature (see Folke et al., 2005).
- **Interconnectivity**. Complexity relates to interconnectivity of domains and functions due to the scale and variety at which climate impacts manifest themselves. As a result of a high degree of interdependencies in our contemporary society we need to take cascade-effects into account in relation to climate change effects (PBL, 2015).

In these characteristic of climate adaptation both a need for adaptive planning and collective action can be identified. Multiplicity and the non-linear character of processes, emphasize a need for adaptive planning, which creates opportunities to reconsider decisions under changing and uncertain conditions. We will discuss different approaches of adaptive planning more in depth in section 2.2.

In particular aspects of uncertainty, contentiousness, multiplicity and interconnectivity highlight the need for collective action. As pointed out by Termeer et al. (2011), a great deal of climate adaptation will result from autonomous or planned actions of private actors. However, many aspects of adaptation have public-good characteristics, requiring collective action. The interconnectivity with between domains and functions asks for participation of a variety of actors In governance processes of climate adaptation. The impact of climate change effects also includes cascading effects. Multiplicity shows the local and regional diversification of effects, which requires collective action within the local and regional context. The characteristic of contentiousness highlight the relevance of different perceptions and the normative character in climate adaptation governance. In the characteristic uncertainty the impact on collective decision-making can be observed, resulting in e.g. delay and additional safety margins.

2.1.2 Complexity of joint action

In this study we consider climate adaptation as processes of joint action. In a complexity point of view we regard this as complex governance processes in which continuous changes take place. Complex governance processes contain diverse elements of structures, content and processes. The high degree of interrelatedness between these elements makes it difficult to create an image about these systems and their boundaries (Flood, 1999: 72). Complexity theories analyse interactions in these processes in terms of interdependencies between systems, subsystems and processes, including how these evolve over time. Complexity comes down to that the real world consists of multiple elements, of different types that are related, but sometimes loosely, and whose mutual relationships are changeable over time (Gerrits, 2012: 16).

As a result of the many interdependencies between actors and problems, successful adaptation strategies depend actions and collaboration of many actors (Koppenjan & Klijn, 2004; Termeer et al., 2011). In response to the interdependencies and uncertainties of climate change effects, there is a temptation by politicians and policymakers to reduce complexity to deal with important issues like climate change. They plea for the establishment of a central decision-making authority in response to fragmented governance structures (Termeer et al. 2011). As a result of studies of emergent networks, governance theories "deliver *the pertinent insight that effective steering comes from joint actions – whether in competition, cooperation of both – than from one single organization that is presumably in charge."* (Teisman & Gerrits, 2014: 18). It is argued by Termeer et al. (2011) that climate adaptations take place in a context of fragmentation. In the regional governance systems there is considerable fragmentation of actions among actors, sectors, and levels. In the challenges of climate adaptation and flood resilience, decision makers need to learn dealing with complex interdependencies between social and ecological systems (Pahl-Wostl et al., 2007; Termeer et al., 2011; Tempels, 2016). Teisman and Gerrits (2014) argue that applying complexity concepts and theories is an important driver in the field of public administration for a new understanding of joint actions.

Today, governors and public managers will define the fragmentation they are facing as problematic (Teisman & Edelenbos, 2011). This also applies to their stakeholders like businesses, inhabitants, NGO's and other governments. They ask for central action, e.g. in the shape of an integrated plan, a central counter for environmental permits or unambiguous policies and regulation. Teisman and Edelenbos distinguish three common types of fragmentation: (1) different policies are conflicting; (2) different organizations and departments are not working together; (3) managers responsible for one policy domain are organizing implementation processes separately and without much knowledge about what the managers in other domains are doing.

Fragmentation is for a large part rather a solution than a problem. Division of labour has been an effective instrument to improve efficiency and productivity of organizations. Moreover, it is also an important driver for specialization, resulting in higher quality products and services. This makes fragmentation an inevitable feature of modern society and organizations (Edelenbos & Teisman, 2011; Buijs, 2018). In these processes of collective action, we have to deal with the challenge of balancing between integration and specialization.

As argued by Termeer et al.(2011) fragmented networks may be better able to provide the governance capacity to enable climate adaptation, than monocentric governance systems (see also Huitema et al., 2008). Fragmented networks contain a higher degree of specialization and flexibility, which enables them to anticipate to unexpected events, creating space for experimentation, variability, dialogue and learning (Termeer et al., 2011; Van Buuren et al., 2013).

In processes of joint actions in climate adaptation, with all actors involved, bottom-up processes of self-organization are supported (Van Buuren et al., 2013). These type of processes of self-organization are also considered as dissipative self-organization, emphasizing a search for coherence between multiple objectives and existing systems boundaries in collective processes (Buijs, 2018). In this approach the multiplicity of climate change and its consequences are acknowledged, aiming to increase the resilience of our society in relation to climate change effects (Van Buuren et al., 2013).

The concept of self-organization questions the guiding ability of single governmental agencies (Buijs et al., 2009). Allen (1996) and Byrne (1998: 149) have argued that governmental decision-making in complex societies does remain possible, but that the effects of governmental actions are highly influenced by the spontaneous actions of many other agents. This underlines the importance of defining the concept of self-organization. Allen (1996: 71) explains the character of self-organization as such: *"In a complex system of interdependent entities the decisions made by individuals, or by collective entities representing certain localities, lead to the emergence of large scale structure, which is not anticipated in their thinking, and which later will in fact determine the choices which are open to them."*

Self-organization is not only about bottom-up processes, but also about conservative patterns, resulting in stabilization in governance processes (see Buijs, 2018]. This means that before we start with adaptive planning to deal with future uncertainties, we do need to take into account the current path and its history in the relevant governance arrangements.

For example fragmentation in the institutional setting can hinder and frustrate the governance of adaptation (Van Buuren et al., 2013). Current institutions are often limited to a specific domain. Within a domain the complexity of challenges likes climate change are not overseen, involved actors might not be aware of the risk of climate change effects for delivering their products and services, and interdependencies in coping with these effects might be ignored. Each relevant domain for climate adaptation have their own policy systems and administrative organization, including formal and informal rules, ambitions, problem-framing, and resources (Termeer et al., 2011). As pointed out by Van Buuren et al. (2013) for the domain of spatial planning: *"uncertainty about climate change and its consequences asks for… robust and sound provisions that safeguard the sustainability and long-term profitability of spatial investments. Perhaps even more important is the need for legal certainty regarding rights and duties, and a clear partition of responsibilities between several public partners and between public and private partners. They are necessary to assure legitimate climate adaptation policies."*

The tendency to establish a central decision-making authority in response to fragmented governance structures (Termeer et al., 2011) can be considered as a conservative pattern of self-organization (Teisman and Edelenbos, 2011; Buijs, 2018). Governors and public managers still look for typical solutions in response to fragmentation, such as integrated policy, organizational unity and powerful implementation. *"All these terms seem to imply the idea that someone is in charge and is able to realize integration… and fulfils the wish to 'get renewed control over' and 'be in charge again'."* (Teisman & Edelenbos, 2011: 102).

Robustness in the current governance arrangement can result in path dependencies. Choices from the past influence future development options, since evolutions and transitions are affected by path dependencies (Martin & Simmie, 2008; Tempels, 2016). These path dependencies can include physical (e.g. structures) and socio-cultural (e.g. identity, institutions) aspects that have impact on the governance of climate adaptation (Boelens, 2009, 2015; Boelens & De Roo, 2016; Tempels, 2016). As argued by Matczak et al. (2016) path dependencies can hamper diversification of flood risk management strategies. *"Within a stable system the chosen management approach has time to mature and to develop, therefore becoming, ideally, more effective and efficient over time. A stable system mostly implies the choice for a limited number of management approaches, which are improved and adjusted over time; but it also implies in most cases a choice against other management approaches…, which are consequently only marginally developed. Due to the path dependency of the existing approach, the capacity to change the arrangement – when facing new* *challenges – might be limited. Especially in the context of increased uncertainty, e.g. due to climate change, this decreased capacity to change might become a disadvantage."*

Not only dissipative processes of self-organization can result in unexpected outcomes in dealing with complexity and uncertainty. This also applies to conservative patterns of self-organization. As argued by Tempels (2016) taking path dependencies into account makes that planning can no longer be seen as controllable processes. This asks for a shift to a more adaptive planning approach. Table 1 (Tempels, 2016: 158) provides an overview of types of planning according to different degrees of uncertainty and the actors, with examples from flood risk management.

		Object of planning **SYSTEM**	
		Known Fixed	Unknown Changing
Context of planning **ACTORS**	Unknown Changing	**collaborative planning** e.g. integrated water management	**co-evolutionary planning**
	Known Fixed	**path-dependent planning** e.g. flood protection	**adaptive planning** e.g. adaptive water management

Table 1 Planning approaches according to different degrees of uncertainty related to the system (or object of planning) and the actors (or the context of planning), with examples from FRM. (Tempels, 2016: 158; adapted from Boelens, 2015).

Facing the challenge of climate change, we have to deal with both an unknown context of planning, since new actors are involved and not all actors are known. Considering the uncertainties of climate change effects and the high variety of affected systems, also the object of planning is unknown and changing. This makes a co-evolutionary planning approach suitable for these processes (Boelens, 2015; Mees et al., 2016; Tempels, 2016; Boelens et al., 2017), which is characterized by *"a reciprocal collaboration between a changing set of actors without fixed aims or objectives. Important processes hereby are self-organization and learning by doing (Verbeek & Boelens, 2016)."* From the discussion above we argue to take both conservative and dissipative self-organization into account in these processes. Furthermore it could be relevant to apply the tension between specialization and integration in considerations about climate adaptation strategies. This can be considered in the light of a co-evolutionary planning approach, in which both the object of planning (systems) and context of planning (actors) evolve in the governance process of climate adaptation.

In the next section we discuss backcasting and DAPP as two approaches of adaptive planning. We consider both approaches as relevant planning approaches for dealing with the complexity and uncertainty of climate change.

2.2. Dealing with complexity and uncertainty

2.2.1. Backcasting

Backcasting was developed in the 1970s in energy studies (e.g. Lovins et al., 1976) and later also applied to sustainability e.g. Robinson (1998). From the early 1990s onwards, it has developed into a participatory approach, especially in Canada, Sweden, and in the Netherlands. It has been applied to various domains including climate adaptation, water, food, cities and regions and the scale varies from the local to regional, national and international. Backcasting can be described as developing and assessing the relative feasibility of alternative futures (Robinson, 1990) or as generating a desirable future, and then looking backwards from that future to the present in order to strategize and to plan how it could be achieved. Key to participatory backcasting are stakeholder participation, learning by those stakeholders and development of visions (Quist, 2007), as well as the methodological aspects including tools and methods. Participatory backcasting has also similarities with transition management (Quist et al, 2011) which is another normative foresight approach.

Backcasting is a suitable approach for climate change adaptation because of their applicability at various scales, their compatibility with various tools and methods and their ability to support various forms of stakeholder engagement. Van der Voorn et al. (2012) developed a methodology that combines the strong points of Adaptive Management and backcasting, which is built and expanded on earlier work by Pahl-Wostl et al. (2007), Quist (2007) and Quist et al. (2011). These methodologies are mutually complementary as backcasting provides Adaptive Management a long time frame for the fulfilment of short- and middle-term management goals and pathways to robust climate change adaptation futures, whereas Adaptive Management emphasises adaptiveness (the ability to cope with uncertainty) and reflexivity (the ability to respond to changing conditions). As depicted in Figure 1, the steps of the BCAM methodology are iterative and cyclic through a feedback loop from step 6 to step 1. Key to the methodology are stakeholder engagement, vision and pathway development and adaptiveness by learning how to manage uncertainties (Pahl-Wostl et al. 2007).

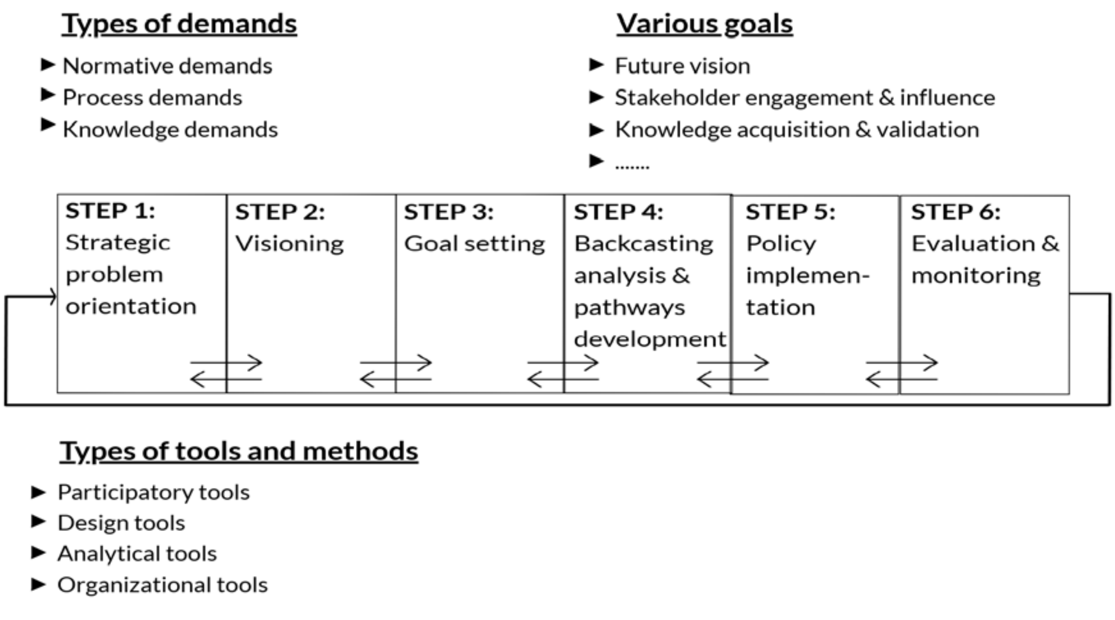

Figure 1: The Backcasting Adaptive Management methodology (Van der Voorn et al., 2017).

Ideally, stakeholder involvement is heterogeneously involving stakeholders from all relevant societal domains like business, research, government and civil society. The latter includes both citizens and NGOs. The BCAM methodology includes normative, process and knowledge requirements as well as various goals related to the future vision(s) concerned, stakeholder involvement and their level of influence in the way issues, problems and potential solutions are framed and resolved in the backcasting study. This integration requires various types of tools and methods (Quist et al. 2011; van Vliet & Kok, 2015) including (i) participatory tools, (ii) design tools, (iii) analytical tools and (iv) organisational tools.

2.2.2. Dynamic Adaptive Policy Pathways

Haasnoot et al. (2013) developed a method for decision-making under uncertain global and regional changes called Dynamic Adaptive Policy Pathways (DAPP). The DAPP approach is based on two complementary approaches for designing adaptive plans: 'Adaptive Policymaking' and 'Adaptation Pathways'. Adaptive Policymaking is a theoretical approach describing a planning process with different types of actions (e.g. 'mitigating actions' and 'hedging actions') and signposts to monitor to see if adaptation is needed. In contrast, Adaptation Pathways provides an analytical approach for exploring and sequencing a set of possible actions based on alternative external developments over time (see Figure 2).

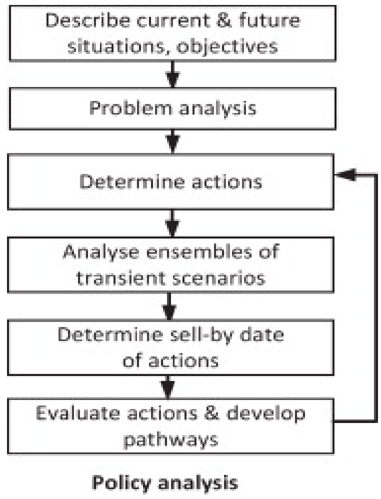

Figure 2. Stepwise policy analysis to construct adaptation pathways (Haasnoot et al., 2013:487)

Adaptation Pathways provides a stepwise approach for developing adaptation pathways (see Figure 3). Central to adaptation pathways are adaption tipping points (Kwadijk et al., 2010), which are the conditions under which an action no longer meets the clearly specified objectives. The timing of the adaptation point for a given action, its sell-by date, is scenario dependent. After reaching a tipping point, additional actions are needed. As a result, a pathway emerges. The Adaptation Pathways approach presents a sequence of possible actions after a tipping point in the form of adaptation trees (e.g. like a decision tree or a roadmap). Any given route through the tree is an adaptation pathway. Typically, this approach uses computational scenario approaches to assess the distribution of the sell-by date of several actions across a large ensemble of transient scenarios. The Adaptation Pathways map, manually drawn based on model results or expert judgment, presents an overview of relevant pathways.

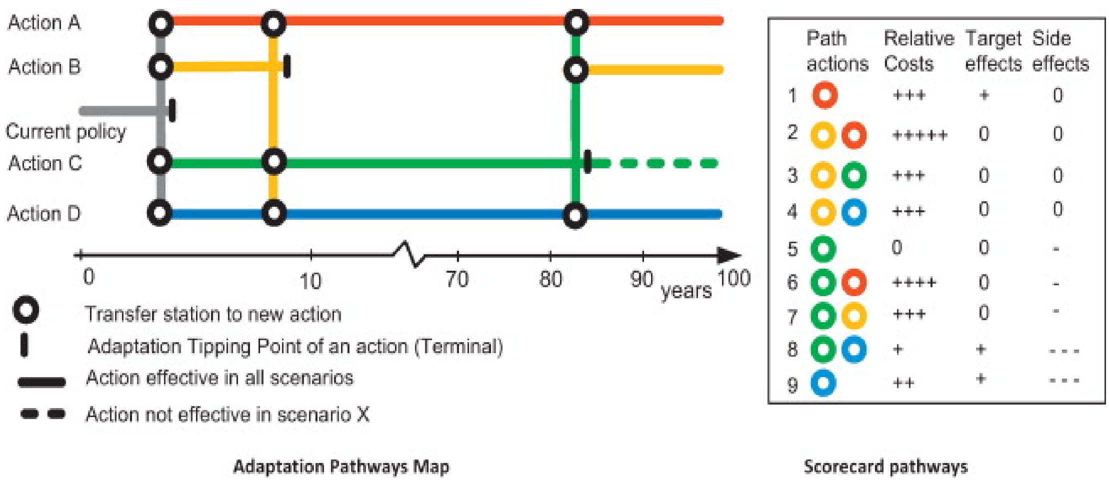

Figure 3. Example of an adaptation pathways map (left) and a scorecard presenting costs and benefits of the 9 possible pathways presented in the map (Haasnoot et al., 2013, 488)

3. Comparison of flood risk governance arrangements in pilot areas

This section describes and compares the governance context of the FRAMES pilots based on the framework by Hegger et al., (2014). We apply the framework within the context of flood risk management. The framework has been developed in the EU FP7 project STAR-FLOOD that focuses on flood risk governance. The project investigates strategies for dealing with flood risks in 18 vulnerable urban regions in six European countries: Belgium, England (UK), France, The Netherlands, Poland and Sweden (Matczak et al., 2016). The project assesses Flood Risk Governance Arrangements (FRGA) from a combined public administration and legal perspective, with the aim of identifying means of strengthening or redesigning flood risk governance to better support goals of enhancing societal resilience to flooding. We here use the definition of FRGAs by Hegger et al. (2014) to refer to the whole of actors, discourses, rules and resources through which Flood Risk Management Strategies (FRMS) are developed and put into practice. We apply the framework to compare flood risk governance arrangements in the corresponding countries of the FRAMES pilots according to the following dimensions:

- *Diversification and dominance of strategies* refers to why is there dominance of some strategies and arrangements in some countries and not in others? What factors explain further diversification of flood risk governance arrangements?
- *Multi-sector governance* relates to factors that explain why flood risk governance either has more differentiated structures, such as sector-based water management, or relies on integrated planning – or even integrated risk management – and what are the possible changes therein?
- *Multi-actor governance* concerns factors that explain why flood risk governance is a responsibility of the state, the market and/or civil society, their interrelationships, and possible changes therein.
- *Multi-level governance* relates to factors that explain why flood risk governance is organised locally, regionally, or nationally, what possible shifts in (de)centralisation we see, and how we can explain them.

The framework provides a lens, through which we can further investigate the robustness of current flood risk governance arrangements of countries included in the FRAMES pilots. Some of these countries were also part of the comparative study conducted in the STAR-FLOOD project (Belgium, UK and The Netherlands). We extended this study by adding Germany and Denmark as hosting countries of several FRAMES pilots and for a complete overview presented below also the analysis by Matzcak et al., 2016). The FRAMES pilots are an indication of flexibility of these countries in their flood risk management strategies. We consider these pilots as explorations for enhanced multilayered approaches for flood resilience. Present-day decisions to be made for the short-term, mid-term and long-term are dependent on the different adaptation pathways along which countries develop, but also uncertainties about the future. As explained in section 2, strategic planning approaches like backcasting and DAPP are particularly suitable for making such decisions for an uncertain future.

3.1. Diversification and dominance of strategies and arrangements

Matczak et al. (2016) found that the hydro-physical characteristics and historical developments in governance style play an important role in the diversification and dominance of strategies and arrangements.

England represents one extreme of the spectrum. It has the highest number of sub-FRGAs and they are relatively balanced. There are several explanations. Initially, the hydro-physical country characteristics are influential: England traditionally faces a broad number of flood types (pluvial, fluvial and coastal threats are considered equally important). These different types of flood ask for specific management approaches and strategies. Furthermore, there is no straightforward legal responsibility of the national government to protect its people from flood risks. This is why different parties, public and private, central and local, are very much involved.

By comparison, Matczak et al. (2016 :73) argue that the Netherlands have a variety of arrangements but is much less balanced, with the water system management arrangement being very dominant. In the Netherlands we see a combination of extremely high vulnerability to floods, mostly coastal and fluvial, a history of flood events, and a historically evolved state responsibility which is institutionalised in a specific sector-based and strong water system sub-FRGA. The government has a legal responsibility for flood risk safety by way of national flood risk standards.

For Belgium the number of sub-FRGAs is somewhere in between extremes. Matczak et al. (2016:73) found that also in Belgium the sub-FRGAs responsible for flood defence give rise to path dependency because they have traditionally been very dominant, partly until today. This is because flood risks in Belgium (and comparable countries like France and Poland) are considered severe, triggered by flood shock events which still function as reference traumas legitimising the traditional approaches.

Furthermore, there has been a dominance of technical expertise since the 19th century. This expertise enabled the state to maintain its legitimacy by being the provider of security and safety (*e.g.* Netherlands: provide habitability. Historically, the areas protected from flooding through dikes were often the areas where, subsequently, high economic development took place. This means that risks increased, which demanded increased (or at least continuous) protection.

In Germany, the Federal Water Act (WHG) and the related state water laws pursued a security approach until 2010, whereas the EU FRM directive and the March 2010 amendment to the Federal Water Act in principle have introduced new standards mainly following a risk approach (Heintz et al., 2012). However, the discussion continues how to achieve the paradigm shift from the safety based approach to the risk based approach also in practice (see Ahlhorn & Bormann, 2015).

In Denmark, there is a tradition of rather strict spatial planning regulations limiting the impact of flooding along the coastline and in case of flooding in uninhabited areas, land is given back to the sea. When flood protection measures are a must, the Danish Coastal Authority mainly opts for beach nourishments or other soft defences.

3.2. Multi-sector governance

Matczak et al. (2016:76) identified differences in the way countries rely on a separate sector domain of water management, or on spatial planning - or even risk management - as a generic governmental coordination mechanism. Very often this is related to historically defined preferences for specific levels of governance, *e.g.* preferences for generic local or national level governance, as well as the *strength* of spatial planning or risk management as a coordinating mechanism.

In all the countries Matczak et al. (2016) found that spatial planning and some specific water management governance institutions co-exist. Both in England and Germany (Heintz et al., 2012) spatial planning plays an important role, *e.g.* in zoning plans or mitigation and flood risk management strategies. In Belgium has a bit of both: water management bodies hold a dominant position within FRM, but - within the period of our research - the use of spatial planning instruments has increased significantly within the framework of integrated water management, particularly in the Flemish region. The same development, at least discursively, can be seen in the Netherlands.

In Denmark, municipalities must translate overall strategies for adaptation to tangible actions at the local level. In Denmark, the sectoral organisation of municipalities, the 2007 reform of local government and the extensive Danish coastline is a basic framework condition for performing this task (Hellesen et al., 2010). The overall principle regarding the implementation and financing of coastal protection is that the *persons who profit* bear the responsibility. Therefore, measures need to be initiated, financed and implemented by landowners or arranged for within the municipalities.

3.3. Multi-actor governance

In each investigated country, Matczak et al. (2016) recognize a certain trend can be witnessed towards greater involvement of market and civil society actors in FRM. This can range from enhanced participatory processes to more comprehensive forms of co-production (*i.e.* participation in both decision-making and delivery) of policies. In all investigated countries, Matczak et al. (2016) confirm that citizens and market actors are increasingly involved in FRM, but the intensity and form of co-production differs significantly.

Matczak et al. (2016:78) argue that the co-production of flood risk management between state and society is strongest in England. They point out the existence of far-reaching cooperation between residents of flood-prone areas and authorities, both in the decision-making phase and in implementation of flood risk measures, *e.g.* through community flood action groups. Matczak et al. also claim that market actors play an important role due to the privatisation of the water sector and high market penetration of flood insurance. In the Netherlands, the government is attempting to raise the flood awareness of the Dutch population to encourage appropriate behaviour, and innovative examples of public participation in FRM decision-making can be found. In Belgium Flanders, a discourse on sharing flood risk responsibilities with societal actors is emergent. Collective stakeholder participation is taking place through the river contracts in the Walloon region of Belgium. In 2006, the insurance sector also entered the domain of FRM.

In the German case, another characteristic of the security approach is a strongly hierarchical planning system that lacks interdisciplinary coordination (Heintz et al., 2012). Due to a long transfer of responsibility from local actors to state actors in flood management, the water authority has a strong influence in terms of legal competences and financial resource.

In Denmark, the privatization of water management has led to the establishment of local water companies that are in charge of water and waste water infrastructures, as well as of securing payment from the private households (Jensen et al., 2016). For many municipalities, the organisation of municipal government, water as a main issue, and subsequently also the more or less formalised structures of collaboration with the private water companies are at centre stage of local adaptation to climate change.

3.4. Multi-level governance

Matczak et al. (2016) acknowledge that a broadening of actors involved in FRM has not only occurred between different policy actors and domains but also ‘up and down the stairs’. In all the countries, changes in flood risk approach have brought shifts in competences and responsibilities between different governmental levels.

When describing and explaining shifts in multi-level governance in different countries, Matczak et al. (2016:82) emphasize that it is important to keep in mind that the scales between these countries differ significantly. Being a federal country, the regions in Belgium (Flanders and Wallonia) function as the ‘national level’ when it comes to water management, but their scale is of course many times smaller than the national level in the UK or Germany. The difference in geographical size of the investigated countries therefore functions as a first explanatory factor for the differences witnessed. Nonetheless, another set of explanatory factors can be identified.

Matczak et al. (2016) found that shifts between different levels of government are part of a wider decentralisation trend in England. In the investigated period, actors at municipal or inter-municipal level have gained competences in flood risk management and other policy domains. In Belgium, competences in water management were transferred from the federal to the regional level in 1988, but this should be seen as a recentralisation rather than a decentralisation process: instead of further decentralising towards the provincial and local level, higher government levels have intensified supervision of municipal FRM. In the Netherlands, responsibilities in flood control are strictly divided between the centralised Rijkswaterstaat and decentralised water boards. Therefore, the Dutch governance structure is considered stable: local actors only become more involved in cases where traditional defence approaches appear unfeasible.

Surminski and Thieken (2017) pointed out that the federal level in Germany only sets general standards for FRM through so-called framework legislation. The federal states (Länder) have the main responsibility for all water issues as well as for civil protection and thus implement the framework legislation and determine actual risk management on the ground (Bubeck et al., 2015). This multilevel governance may result in different management approaches.

In 2008, Denmark launched its first national climate adaptation strategy, *Strategy for adapting to climate changes in Denmark* (Danish Government, 2008) in which climate adaptation was put on the agenda at national and local level. Focus in the strategy is on presenting a range of options that local government can take in order to prepare for a changing climate of the future, and on assessing the risks of impacts for particular types of Danish landscape and society (Jensen et al., 2016). In 2018 flood risk management responsibilities will become more decentralized to the local level in Denmark.

Characteristics of governance	**Belgium**	**England**	**Netherlands**	**Germany**	**Denmark**
Diversification & dominance	Moderately diversified, defence still important	Highly diversified, quite balanced	Low diversification, defence dominant	High diversified, focus on defence	Highly diversified, focus on defence
Multi-sector	Water sector and spatial planning gaining equal importance; water sector still important	Multi-sector involvement & integrated by spatial planning	Water sector dominant	Multi-sector involvement & integrated by spatial planning	Multi-sector involvement (landowners and farmers have a say; landowners do not pay)
Multi-actor	Public (state dominant)	Public & private	Public (state dominant)	Public (state and federal states) dominant	Public & private
Multi-level	Decentralised, tendency towards centralisation	Central and local level	Both central and regional level	Central guidance & decentralization to federal state & local level	Central guidance & ongoing decentralization to local level

Table 2. Flood risk governance in countries of pilot studies. Adapted from Matzcak et al. (2016: 72)

4. Decision-making and adaptive planning in multi-layered safety pilots

This section presents country comparisons based on results of two FRAMES workshops: The Decision Support System (DSS) workshop (November, 2017) and The Dynamic Adaptive Policy Pathways (DAPP) workshop (February, 2018). The DSS workshop and involved all partners of the FRAMES consortium (approximately 30 participants from regional authorities, agencies, NGOs and knowledge institutes, operating in the field of flood risk management, spatial planning, infrastructure, crisis and emergency management). Building on the Backcasting Adaptive Management (BCAM) methodology, the aim of the workshop was to stimulate transnational collaboration about core themes in the approach of the FRAMES project. The aim of the workshop was to collect information and experiences from the pilots, which will be used as input for the development of a Decision Support System. The workshop also facilitated knowledge exchange among the project partners to enable transnational learning processes. The international project meeting was used to discuss the most burning questions, such as:

- Which are *key insights* from the pilots regarding multilayered safety and adaptive planning?
- What are *the uncertainties and knowledge* gaps?
- What are the *similarities* and *differences* between the pilots and transnational?
- What *lessons* can be drawn from the comparison?

As such, these pilots provide key insights into the complexity in decision making and the different points of departures for decision makers in developing multilayered strategies for flood resilience, but also how strategic planning approaches like backcasting and DAPP could support them in doing so. The DAPP workshop was jointly organized by Danish Coastal Authority, Kent Count Council and HZ University of Applied Sciences. The aim of the workshop was to develop an understanding of the underlying principles of the DAPP approach and develop adaptive planning maps and to identify gaps in DAPP based on project needs and potential solutions to gaps in DAPP model. The workshop provided insights into weaknesses and strengths of backcasting and DAPP as well as the trade-offs to be made when applying these approaches separately or in combination. Based on these insights, we explore the possibilities for a decision support system that supports decision makers in developing robust and flexible adaptive strategies for flood resilience.

4.1. Thematic comparison of pilots

This section presents a comparison of themes that play an important role in the pilots in each country. The pilots are context dependent, as they depart from the dominant national/regional flood risk governance strategies and the climate adaptation and flood risk management challenges they are facing. The presented results in this section are not a complete overview of all relevant factors in flood resilience in general. The pilots have identified challenges faced in climate change adaptation interventions related to specific themes, which relate to the multilayered safety concept. Spatial planning and critical infrastructure are key themes for the 2nd layer of proaction measures in relation to flood risk management. Evacuation planning and social capital are highly relevant for the 3rd layer, focusing on emergency response. Table 3 shows the main focus of each pilot. In practice and reflection a high degree of interdependencies between these themes and layers are observed. For example, in the Reimerswaal pilot (NL) cascading effects of failure of critical infrastructure has impact on evacuation planning. On the other hand, spatial planning is highly relevant to protect critical infrastructure.

FRAMES Pilot	Spatial planning	Critical infrastructure	Evacuation planning	Social capital
Albasserwaard (NL)	■		■	
Kent (UK)			■	■
Upper Dent (UK)	■			
Lustrum Beck (UK)				■
Southwell (UK)	■			
Floodproof electricity grid Zeeland (NL)		■		
Reimerswaal (NL)		■		
Sloegebied (NL)			■	■
Roskilde (DK)	■			
Vejle & Solrod-Koge (DK)	■			
Wesermarch (DE)	■	■	■	
Ninove South-Burchtdam (BE)	■			■
Denderleeuw (BE)	■			■

Table 3: Main focus themes of multi-layered safety pilots in FRAMES

4.1.1. Type of measures

Different types of measures were suggested for the themes on critical infrastructure and spatial planning. For social capital and evacuation planning, no specific measures were identified but rather some long-term strategic directions like e.g., insurance and collaboration between local and national government authorities and agencies. This is due to considerable knowledge gaps in improving social capital and evacuation planning (see below). The pilots will work for next years on these issues. Identification of these issues and dialogue on these issues can facilitate transnational learning. The flood risk governance arrangements as pointed out in section 3 should be kept in mind.

4.1.2. Knowledge gaps

Different knowledge gaps were identified for all themes. For the theme on critical infrastructure, knowledge gaps relate to measures and contextual developments. The knowledge gaps identified for spatial planning relate to obstacles from the past that may impede the implementation of nature-based solutions. Knowledge gaps recognised for social capital concern issues related to improving community resilience. Two approaches were suggested to bridge the knowledge gaps. With regard to evacuation planning, knowledge gaps relate to the coordination and planning of evacuation in crisis events. It was also noticed that evacuation planning has major interdependencies with other themes.

4.1.3. Articulation of uncertainties

For critical infrastructure, spatial planning and evacuation planning, uncertainties are addressed by the knowledge gaps. For social capital, there are also uncertainties identified concerning responsibilities of authorities.

4.1.4. Fragmentation and integration

For critical infrastructure, the possibility to withdraw certain existing infrastructure needs to be assessed. Trade-offs have to be made between existing and future infrastructures, focusing on a resilient infrastructure system in flood prone areas. From the pilot in Reimerswaal (NL) the relevance of interdependencies and cascading-effects has become clear. Path dependency in spatial planning, dealing with the constraints of historic developments and mechanisms of risk management, can be an obstacle for solutions and planning in the long run. When it comes to social capital, it was recognized that different scales require different approaches. It was considered important to identify which individuals or communities are at risk and which problems do they face now or later – and who is responsible. For evacuation planning, emergency management needs to take into account that the capacity of roads and transportation is not sufficient due to high density and diversity of people in many regions. Some people are difficult to evacuate, linking to social capital and the health care sector. Evacuation planners also need to inform people in time and identify safe places, which involves authorities and the local press.

	Critical infrastructure	**Spatial planning**	**Social Capital**	**Evacuation planning**
Type of measures (short-, mid-, long-term)	Short-term; mid-term; long-term	Short-term; mid-term; long-term	Some long-term strategic directions	Some long-term strategic directions
Knowledge gaps	Urgency & costs of measures; political, economic and demographic developments	Obstacles rooted in the past, impeding nature-based planning;	Knowledge gaps in improving community resilience (two approaches to bridge the knowledge gaps)	Aspects related to coordination and planning of evacuation in crisis events; Overlap with other themes
Articulation of uncertainties	Addressed by knowledge gaps	Addressed by knowledge gaps	Uncertainties about responsibilities of authorities	Addressed by knowledge gaps
Fragmentation/ integration	Trade-offs between existing & future infrastructures; Cascading effects	Path dependency in spatial planning Sectoral conflicts	Switching between different levels of scales require different approaches Responsibilities	Regional differences in evacuation planning High interdependency with other systems

**Short-term = 5 years; Mid-term = 5 – 25 years; Long-Term = >25 years*

Table 4: Uncertainties and fragmentation/integration in adaptive planning for the pilot areas

4.2. Comparison of planning aspects

This section presents a comparison of certain planning aspects regarding the pilots. The pilots can be compared in terms of time orientation, knowledge or awareness of climate change impacts with business as usual (BAU) and articulation of a desired situation (see Table 5). Large diversity can be found in the pilots. To support the development of the DSS, it is useful to compare the pilots and investigate what can be learnt from this comparison.

	Kent (UK)	**Vejle (DK)**	**Wesermarsch (GE)**	**Alblasser waard (NL)**	**Reimerswaal (NL)**	**Denderleeuw (BE)**
Time orientation*	Mid-term/ long-term	Long-term	Mid-term/ long-term	Mid-term/ long-term	Mid-term/ long-term	Long-term
Knowledge of climate change impacts with business as usual	Yes, increased flooding, deaths, costs & risks	Yes, main sources of floods	Yes, floods and droughts. Focus on potential sectoral conflicts of adaptation measures	Yes, increased vulnerability to flooding & water shortage	Yes, increased risks of damaged infrastructure	Yes, but focus on heavy rain floods (T10 category)
Articulation of desired situation	Fundamental shift vulnerable communities in flood risk management	Shift to municipal focus in spatial planning	Shift to integrated planning approach (through tipping points)	Shift to integrated spatial planning; shift from protection to prevention	Shift to spatial planning with focus on resilient infrastructure	Shift to planning combining various actors in business, civic and public

Table 5: Comparison of planning aspects in pilots

4.2.1. Time orientation

For each pilot, participants applied a mid-term and/or long-term perspective on climate adaptation planning. It is also acknowledged by several participants that this should not be a reason to wait for the development of parallel or alternative strategies regarding flood resilience. One of the observed risks is a short term focus in political processes (elections, delusions of the day), which are not connected with long term planning in relation to flood risk management. Both development of parallel strategies and investments in measures for current strategies require a long term focus and commitment of government and other stakeholders. Communities and the private sector need help from government to deal with uncertainties in relation to climate adaptation.

Time and in particular the combination between long-term planning and short term action is important to the learning process of pilots to explore new flood risk management strategies. This means long term planning approaches like DAPP and backcasting are important, but also the current governance setting and management of flood risk. In this regard, it is important to link future uncertainties with the complexity of present day decision-making.

4.2.2. Knowledge of climate change impacts with business as usual

In each pilot, participants seem to understand the impact of climate change under business as usual conditions. Compared to the other pilots, the focus of the German Wesermarsch pilot is not so much on climate change impacts, since impact studies are available already (e.g., Bormann et al., 2012), but rather on the potential sectoral conflicts between adaptation measures. This focus is rooted in the approach of tipping points, in which climate change impacts and other events are considered as triggers for change in current practices. This approach is part of the DAPP approach, which can be used to identify tipping points as the expiry date of current practices and/or measures, but also to explore potential conflicts between adaptation measures. During the FRAMES DAPP Workshop, an approach based on the DAPP approach and the BackCasting Adaptive Management (BCAM) methodology was tested for the pilot region Solrød Køge (DK). More in general the Danish flood risk management approach has been compared with the approach in UK and the Netherlands. The workshop demonstrated that applying the DAPP approach is data intensive. For instance, a substantial amount of data of several systems is needed to identify or define tipping points.

4.2.3. Articulation of desired situation

A desired situation was articulated for each pilot. For three pilots, the preferred situation reflects a desire for a shift to spatial planning with a municipal focus (Vejle), an integrated focus on prevention (Alblasserwaard) and focus on resilient infrastructure (Reimerswaal). By comparison, the preferred situation for the Wesermarsch and Denderleeuw pilots reflects a desire for a more integrated planning approach that takes into account the interplay of short-, mid-, long-term interventions (Denderleeuw) or tipping points (Wesermarsch). For the Kent pilot, the preferred situation focuses on vulnerable communities in flood risk management.

5. Discussion and conclusions

In this paper, we have presented preliminary findings of the FRAMES project that provides insights into how to cope with complexity and uncertainty in decision making on flood resilience from a multilayered safety approach. In section 2 we have presented several relevant theoretical perspectives on the complexity of climate adaptation, complexity of joint action and planning approaches to deal with the challenges of climate adaptation. In section 3, we have compared the flood risk governance arrangements in five countries in the North Sea Region (Belgium, Denmark, Germany, The Netherlands and United Kingdom), for which we have employed the study conducted by STAR-FLOOD (Hegger et al., 2014; Matzcak et al., 2016). This comparison provided useful insight into the diversity of the FRGAs in the countries and provides the opportunity to consider pilots in their own governance context.

In section 4, we have compared the pilots based on the elements of the disaster management cycle and identified themes in the FRAMES project, which include spatial planning, critical infrastructure, social capital, and evacuation planning. The focus in the pilots is not as not black and white as presented in Table 3. There are many shades of grey as a result of strong interdependencies between systems and strategies, as discussed in section 2.1.2. The pilots also demonstrate the known and unknowns regarding the object of planning and the context of planning. In each pilot there is knowledge of climate change impacts, business as usual practices, but there are knowledge gaps yet to be bridged when it comes to their impact on spatial planning, critical infrastructure, social capital, and evacuation planning. These knowledge gaps are surrounded by uncertainties.

From this comparison of flood risk governance arrangements the following patterns were identified. First, dominance and diversification link to conservative and dissipative patterns of self-organization. Conservative patterns contain a risk of path dependency. In the Netherlands, Belgium and England, for example, the sub-FRGAs responsible for flood defence give rise to path dependency because they have traditionally been very dominant, partly until today. Second, the multisector character emphasized the relevant systems involved. This links to the debate about specialization and integration. Dealing with climate change effects ask for an integrated approach, but sectors also represents specialization. Climate change not only asks for integration, but also more specific knowledge within existing domains. In the Danish case, for instance, the Government launched a national climate adaptation strategy in which climate adaptation was put on the agenda at national and local level. The strategy includes a range of options that local government can take in order to prepare for a changing climate of the future, and on assessing the risks of impacts for particular types of Danish landscape and society. However, the municipalities must translate overall strategies for adaptation to tangible actions at the local level. This shows the risk of fragmentation in adaptive planning for climate change. Not all affected systems and sectors are known beforehand (see Table 1 by Tempels, 2016). Fragmentation and a desire for integration give rise to a need for connective capacity in these complex governance processes (Edelenbos et al., 2013; Buijs, 2018).

Third, multi-actor governance suggests that not all actors are known and their roles are changing. In line with Matzcak et al. (2016), a broadening of actors involved in FRM has not only occurred between different policy actors and domains but also ‘up and down the stairs’. In all the countries, changes in flood risk approach have brought shifts in competences and responsibilities between different governmental levels. In Denmark, for example, the overall principle regarding the implementation and financing of coastal protection is that the *persons who profit* bear the responsibility. Therefore, measures need to be initiated, financed and implemented by landowners or arranged for within the municipalities.

Furthermore, multilevel governance is observed in the importance of level of scale. The importance of the country level is pointed out in the framework of Hegger et al. (2014). The pilots in our study are considered as regional explorations to enhance multilayered approaches for flood resilience. As pointed out by Termeer et al. (2011) and Van Buuren et al. (2015), in the introduction, there is a prime role for regions in the challenge of climate adaptation. There is a need for regional processes of joint searching and learning. These pilots provide further insight into the different points of departures for decision makers in developing multilayered strategies for flood resilience, but also how strategic planning approaches could support them in doing so.

The pilots studies can help to understand the supporting role of backcasting and Dynamic Adaptation Policy Pathways (DAPP) in making robust decisions under deep uncertainty. First, both approaches support dealing with complexity that is inherent to dynamic adaptive processes, but also the governance context within which these processes unfold. DAPP has been criticized for adopting an overly unicentric perspective on governance (see Wise et al., 2014), but Timmermans et al., (2015) do not consider unicentrism as an intrinsic property of DAPP. DAPP offers a more rational approach for long-term planning which require a vast amount of data and knowledge on boundary conditions and expert judgements. Depending on the availability of data of included systems, DAPP can be used to develop adaptation pathways and identify sell-by-dates or tipping points of current strategies or pathways. Due to its data intensive nature, DAPP tends to increase complexity rather than reducing it, concerning the object of planning (systemic knowledge). DAPP integrates a process approach for adaptive planning but requires a clear orientation on decision-making and tooling for an interactive approach (see Timmermans et al., 2015). This makes DAPP less sensitive to normative aspects, like stakeholder perceptions.

By comparison, backcasting is better suited to account for such normative aspects, due to its participatory and normative nature. Backcasting offers stakeholders to participate in different stages of decision making, which departs from a shared vision that reflects the different perceptions, interests and world views of stakeholders (see Van der Voorn et al., 2012). Backcasting can be seen as an approach for (joint) complexity reduction of data, as it acknowledges the negotiability of data in a multi-actor process. Stakeholder set normative, process and knowledge (data) requirements as well as various goals related to the future vision(s) concerned, stakeholder involvement and their level of influence in the way issues, problems and potential solutions are framed and resolved in a backcasting study (see Van der Voorn et al., 2017). In this regard, backcasting tends to be more goal-oriented than DAPP as the degree of complexity depends much more on how joint action is shaped in a participatory way. The backdraw of a complexity reductionist approach is that visions of future may hide the full complexity of the systems under study. To compensate for this shortcoming, various tools and methods like, for example, GIS modelling and Source-Pathway Receptor mapping can support the combined application of backcasting and DAPP.

Based on pilots, we explore the possibilities for a decision support system (DSS) that supports decision makers in developing robust strategies for flood resilience. This reflects on the diversity of backcasting and DAPP. We consider backcasting as an example of collaborative planning and DAPP as an example of adaptive planning, but we also recognize the additional value of combining both approaches in a co-evolutionary planning approach. For example, both approaches have a different point of departure considering time. Backcasting is retrospective in nature as it looks back from the future, whereas DAPP looks forward based on current or business as usual practice. At the start backcasting requires more knowledge about the actors and their desires. It embraces complexity from an actor perspective, the context of planning (see Table 1). Also a certain level of knowledge about the current system state is required. DAPP requires more knowledge about the systems and its vulnerabilities. DAPP embraces the complexity of systems and their interdependencies. It also implies a certain degree of knowledge about current responsibilities. When combined with DAPP, backcasting can be useful to account for both the normative and objective aspects of the sell-by-dates or tipping points: is it desirable to continue with current practices after the sell-by-dates of flood risk management strategies?

Last but not least, the potential of backcasting has not yet become mainstream in climate adaption planning. Backcasting has been demonstrated as a suitable for climate change adaptation because of their applicability at various scales, their compatibility with various tools and methods and their ability to support various forms of stakeholder engagement (see Van der Voorn et al., 2017). DAPP appears to be a promising approach for adaptive policy making that is rapidly gaining ground as the primary focus in adaptation science, but it requires a clear orientation on decision making and tooling for an interactive approach (Timmersmans et al., 2015) in addition to the current focus on fit for purpose modelling (see Haasnoot et al., 2013). The disconnection between backcasting and DAPP in the current literature offers interesting pathways for co-evolutionary planning.

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