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Research, part of a Special Feature on Toward More Resilient Flood Risk Governance

Toward more flood resilience: Is a diversification of flood risk management strategies the way forward?

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ABSTRACT. European countries face increasing flood risks because of urbanization, increase of exposure and damage potential, and the effects of climate change. In literature and in practice, it is argued that a diversification of strategies for flood risk management (FRM), including flood risk prevention (through proactive spatial planning), flood defense, flood risk mitigation, flood preparation, and flood recovery, makes countries more flood resilient. Although this thesis is plausible, it should still be empirically scrutinized. We aim to do this. Drawing on existing literature we operationalize the notion of "flood resilience" into three capacities: capacity to resist; capacity to absorb and recover; and capacity to transform and adapt. Based on findings from the EU FP7 project STAR-FLOOD, we explore the degree of diversification of FRM strategies and related flood risk governance arrangements at the national level in Belgium, England, France, the Netherlands, Poland, and Sweden, as well as these countries' achievement in terms of the three capacities. We found that the Netherlands and to a lesser extent Belgium have a strong capacity to resist, France a strong capacity to absorb and recover, and especially England a high capacity to transform and adapt. Having a diverse portfolio of FRM strategies in place may be conducive to high achievements related to the capacities to absorb/recover and to transform and adapt. Hence, we conclude that diversification of FRM strategies contributes to resilience. However, the diversification thesis should be nuanced in the sense that there are different ways to be resilient. First, the three capacities imply different rationales and normative starting points for flood risk governance, the choice between which is inherently political. Second, we found trade-offs between the three capacities, e.g., being resistant seems to lower the possibility to be absorbent. Third, to explain countries' achievements in terms of resilience, the strategies' feasibility in specific physical circumstances and their fit in existing institutional contexts (appropriateness), as well as the establishment of links between strategies, through bridging mechanisms, have also been shown to be crucial factors. We provide much needed reflection on the implications of this diagnosis for governments, private parties, and citizens who want to increase flood resilience.

Key Words: *Belgium; capacity to absorb and recover; capacity to resist; capacity to transform and adapt; comparison; diversification of flood risk management strategies; England; Europe; evaluation; flood risk governance; France; the Netherlands; Poland; resilience; Sweden*

INTRODUCTION

The vast literature on the need to manage the resilience of social-ecological systems has paid much attention to flood risk management (FRM) and its strategies (Aerts et al. 2008, Klijn et al. 2008, Wardekker et al. 2010, Kellens et al. 2013). Five basic types of strategies can be identified (Table 1): flood risk prevention (through proactive spatial planning), flood defense, flood risk mitigation, flood preparation, and flood recovery (Hegger et al. 2014). In literature and in practice, it is increasingly argued that a diversification, coordination, and alignment of these flood risk management strategies (FRMSs) will make urban agglomerations more resilient to flood risks, e.g., by focusing on both probability and consequence-reducing approaches, by tailoring these approaches to the magnitude of the risk and to the types of flooding, e.g., pluvial, fluvial, coastal, and flash floods (Aerts et al. 2008, Wardekker et al. 2010, Innocenti and Albrito 2011, van den Brink et al. 2011, Hegger et al. 2014, Mees et al. 2014). Diversification would lead to more redundancy and choice options, flexibility, and adaptability of flood risk management. This is said to require new governance arrangements behind the strategies, changes in existing arrangements, and their linking together and alignment (Hegger et al. 2014). Flood risk governance arrangements (FRGAs) have been defined as institutional constellations resulting from an interplay between actors and actor coalitions involved in all policy domains relevant for flood risk management (including water management, spatial planning, and disaster management) as well as their dominant discourses, their formal and informal rules of the game, and the power and resource base of the actors involved (Hegger et al. 2014, see also Van Tatenhove et al. 2000, Arts et al. 2006).

Although it makes intuitive sense to see a causal link between the presence of a diverse range of FRMSs and the degree of flood resilience of an urban agglomeration, the empirical evidence base for the existence of this link is still tentative. Moreover, empirical data may also point us to the need to refine and nuance the diversification thesis. We aim to address this knowledge gap and intend to contribute to the literature on resilience of social-ecological systems and flood risk governance by confronting theoretical insights from this literature with empirical evidence. To achieve the research aim, the following research questions will be addressed:

1. Which desired capacities for determining the resilience of vulnerable areas to flood risks can be derived from the literature on resilience of social-ecological systems and flood risk governance?

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Table 1. Five types of flood risk management strategies (adopted from Hegger et al. 2014).

Strategy	Characteristics
1. Flood risk prevention	Prevention measures aim to decrease the consequences of flooding by decreasing the exposure of people/property, etc., via methods that prohibit or discourage development in areas at risk of flooding (e.g., spatial planning, reallotment policy, expropriation policy, etc.). The main focus of the strategy is on "keeping people away from water" by building only outside flood-prone areas.
2. Flood defence	Flood defence measures aim to decrease the probability of flooding areas through infrastructural works, such as dikes, dams, embankments, and weirs, mostly referred to as "flood defence" or "structural measures" through measures that increase the capacity of existing channels for water conveyance (natural or man-made) to increase space for water (laterally or vertically) or the creation of new spaces for water retention outside of the area to be defended. In brief, the focus is on "keeping water away from people."
3. Flood risk mitigation	Flood risk mitigation focuses on decreasing the consequences of floods through measures inside the vulnerable area. Consequences can be mitigated by a smart design of the flood-prone area. Measures include spatial order, water retention within the protected area, or (regulations for) flood-proof building. Flood risk mitigation thus includes all measures to flood-proof properties as well as measures to retain or store water in or under the flood-prone area.
4. Flood preparation	Consequences of floods can also be mitigated by preparing for a flood event. Measures include developing flood warning systems, preparing disaster management and evacuation plans and managing a flood when it occurs.
5. Flood recovery	This strategy facilitates a good and fast recovery after a flood event. Measures include reconstruction or rebuilding plans as well as compensation or insurance systems.

2. To what extent can we observe the presence of a diversified portfolio of FRMSs, in terms of the implementation of measures belonging to different FRM strategies and/or the presence of FRGAs necessary to implement the strategies in Belgium, England, France, the Netherlands, Poland, and Sweden?
3. What are the achievements of the aforementioned countries in terms of the desired capacities for flood resilience and what are similarities and differences?
4. Which lessons can be derived from the previous analysis and evaluation for future flood policies on the EU and national levels?

Answering the question of "what should be made resilient to what" (Lebel et al. 2006) our unit of analysis will be the overarching national policies and approaches regarding FRM in six European countries. These countries are interesting because they are all Member States of the European Union that are currently implementing the EU Floods Directive (FD, 2007/60/EC) but differ tremendously from one another in terms of physical conditions, actual flood experience, their departure point in terms of the FRMSs and FRGAs that are in place, and their economic, social, administrative, and legal context, among other things (Hegger et al. 2013). Although there is spatial diversity within the countries, most of them can be said to have an overall national approach to FRM (In Sweden, FRM is however embedded in other policy areas; Hegger et al. 2013). By undertaking national level comparisons between countries that are diverse in their characteristics, we will be able to acquire detailed insights into the intricate link between the implementation of strategies and the degree of flood resilience at the national level.

Because resilience is a widely discussed and contested concept, we deem it undesirable to try to favor a single understanding of resilience over all others. Instead, we argue for a multidimensional evaluation, using three capacities: "capacity to resist," "capacity to absorb and recover" and "capacity to transform and adapt," which are representative of three major streams of thought in resilience and flood risk governance literature.

RESILIENCE IN FLOOD RISK GOVERNANCE: A FRAMEWORK

Three dominant perspectives on resilience

The use of the term resilience and the application of a resilience perspective both have a long history, dating back to the 1960s and 1970s when the perspective was developed within the field of ecology (e.g., Holling 1973, see Folke 2006 for an overview). The term's application to the analysis of social-ecological systems has occurred more recently (e.g. Olsson et al. 2004, Walker et al. 2004, Folke et al. 2005, Folke 2006, Lebel et al. 2006, Davoudi et al. 2012, Keessen et al. 2013, Wiering et al. 2015). As of now, the literature on resilience has expanded far beyond its initial focus on ecological systems and has filtered into discussions of social, institutional, economic, policy, and legal systems. Also the literature on flood risk management has adopted the resilience concept (e.g., Klijn et al. 2004, Wardekker et al. 2010, Mens et al. 2011, Hegger et al. 2014, Wiering et al. 2015). Although the resilience notion is conceptualized in many different ways, most contributions view resilience as a property of a system (Mens et al. 2011, Wiering et al. 2015). It is a difficult and perhaps fuzzy term, because it includes both stability (resistance to change) and change (adaptability) components (Reghezza-Zitt et al. 2012, Wiering et al. 2015).

The main distinctions made in literature are those between forms of (i) engineering, (ii) ecological, social-ecological, and (iii) evolutionary resilience (Fiering 1982*a,b,* Folke 2006, Davoudi et al. 2012).

1. Engineering resilience emphasizes resistance of a system, as part of its stability, with a focus on the ability of a system to "resist and return" to some original (satisfactory) state (bounce back). This is related to notions of efficiency and control-over-nature typically adopted in resource and environmental management (Holling 1996).
2. A second understanding of resilience is close to the first, but now smaller changes are needed to preserve the stability of the system on a larger temporal scale or on a higher level. This is resilience aimed at long-term persistence and

robustness. Walker et al. (2004) refer to this notion of resilience by referring to "the capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure, identity, and feedbacks." This notion has been adopted by the Resilience Alliance, that defines resilience as "the capacity of a social-ecological system to absorb or withstand perturbations and other stressors such that the system remains within the same regime, essentially maintaining its structure and functions. It describes the degree to which the system is capable of self-organization, learning and adaptation" (http://www.resalliance.org/key-concepts). The Resilience Alliance definition also includes a (gradual or step-wise) change of systems to secure long-term stability. As Folke et al. (2010) stress, the notions of adaptability and transformability are closely intertwined. "Transformational change at smaller scales enables resilience at larger scales" (Folke et al. 2010).

3. A third understanding of resilience is even more focused on systems' adaptability and transformability (Davoudi et al. 2012). The literature on adaptive governance reflects this third understanding. Chaffin et al. (2014), in their synthesis of literature on adaptive governance, hold that adaptive governance "is essential for dealing with complexity and uncertainty associated with rapid global environmental change." Social-ecological systems should be managed "holistically for either increased resistance to undesirable change or the ability to transform a system to a more desirable state" (Chaffin et al. 2014). Adaptive governance is seen as a precondition for achieving adaptive management (Chaffin et al. 2014), which can be understood as the enabling of "a social-ecological system to sustain itself through learning-by-doing and cooperation and to avoid collapse, while enhancing a system's capacity to respond to changing circumstances" (Den Uyl and Driessen 2015:189, based on Walters and Holling 1990, Lee 1993, Berkes et al. 2003, Olsson et al. 2004, Armitage et al. 2008). This perspective sees adaptability and transformability as preconditions of resilient systems, and emphasizes change. This literature on adaptive governance often stresses that system resilience will benefit from a variety of pathways or strategies. Scholars stress diversity, polycentricity, and flexibility (e.g., Folke et al. 2005, Pahl-Wostl et al. 2007, for a critical discussion see Bakker and Morinville 2013).

Translating the perspectives into desired capacities for resilience

The three main perspectives of resilience outlined above can be translated into corresponding desired capacities for evaluating the flood-resilience of vulnerable urban agglomerations: capacity to resist, capacity to absorb and recover, and capacity to transform and adapt (Alexander et al. 2016*a*).

Capacity to resist

Capacity to resist is seen as the ability to withstand disturbances (Klijn et al. 2004, Mens et al. 2011). This resonates with the Oxford Dictionary's definition of resistance, being "the ability not to be affected by something, especially adversely." It is often understood in the sense of increasing threshold capacity, being the magnitude of a disturbance, e.g., high river discharges, storm surges, or extreme precipitation events, needed to do harm (De Graaf et al. 2009). Resistance-like measures include dikes, dams, and embankments or water retention and can hence be linked conceptually to the timely and effective implementation of the strategies of flood defense and flood risk mitigation introduced above. The question of whether resistance measures are to be seen as an aspect of resilience is debated in literature. Proponents (e.g., Aerts et al. 2008, De Graaf et al. 2009) argue that they are inherently part of a balanced portfolio of FRM measures - reducing the need to have a capacity to absorb or adapt. Opponents (e.g., Holling and Meffe 1996, Liao 2012) hold that resistance is detrimental to urban areas' capacity to absorb or adapt and leads to a false sense of safety. We do, however, accept resistance as an enhancing factor for resilience. Because it represents a significant part of the large body of literature on flood-proofing countries and regions, it would not be legitimate to a priori exclude it as a relevant part of the notion of flood resilience.

Capacity to absorb and recover

We understand the notion of "capacity to absorb and recover" as the extent to which flood-prone areas can absorb disturbances without shifting into a different, less satisfactory, state. Although resistance is about the possibility not to be negatively affected by a disturbance, the capacity to absorb and recover refers to situations where a system is affected, but is still capable of responding and recovering (Mens et al. 2011). This notion is similar to what some contributors to the flood risk governance debate have termed the "resilience" of flood risk systems (Klijn et al. 2004). This conceptualization is, however, narrower than that found in literature on the resilience of social-ecological systems (e.g. Folke 2006, Liao 2012). Capacity to absorb and recover links up with the notion of social-ecological resilience discussed above. It can also be linked, conceptually, to the timely and effective implementation of the strategies of flood preparation and flood recovery introduced in the introduction as well as more natural ways of flood defense (including giving rivers more room).

Capacity to transform and adapt

The adaptive capacity of social-ecological systems has been defined as "the ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences" (Millennium Ecosystem Assessment 2006, Glossary:599). For our research on flood risk governance, the assessment of adaptive capacity includes that of institutions and of communities (Davoudi et al. 2012). For dealing with flood risks, institutions should be prepared for dealing with several kinds of uncertainty and surprise, including external drivers (Folke et al. 2005). Besides that, these institutions need to initiate deliberate change to achieve the small scale transformations that allow the social-ecological system as a whole to remain stable in the long term (Folke et al. 2010). As several authors have argued, the capacity to learn—about how to address circumscribed problems as well as about ways in which problem definitions might need to be revisited (e.g., Lebel et al. 2006, Pahl-Wostl et al. 2007)—is an inherent aspect of the capacity to transform and adapt (Folke et al. 2005, Pahl-Wostl et al. 2007, Mostert et al. 2008, Raadgever et al. 2008). Learning has been found to be enhanced by participation and deliberation, as well as flexibility and more decentralized steering modes (Folke et al. 2005, Pahl-

Table 2. Three capacities of resilience in application to floods: definitions, indicators, and sources

Form of capacity	Adopted definition	Indicators	Sources
Capacity to resist	The ability not to be adversely affected by floods, by increasing the threshold above which floods can cause harm	Timely implementation of effective measures that allow resistance to floods, e.g., structural measures or upstream retention	Klijn et al. 2004, Aerts et al. 2008, De Graaf et al. 2009, Mens et al. 2011
Capacity to absorb and recover	The ability of a flood-affected system to remain functioning, respond to a flood, and recover (without shifting to a different system state)	Timely implementation of effective measures that allow for response to and/or recover from floods: presence of flood awareness, flood mitigation measures, insurance systems, forecasting and warning systems, crisis management	Klijn et al. 2004, Folke 2006, Liao 2012, Mens et al. 2011
Capacity to transform and adapt	The ability of a system to adjust to external drivers affecting the exposure of people and economic assets to floods (including climate change, climate variability, and changes in extremes, demographic changes, and changes in urbanization patterns) to moderate potential damages, to take advantage of opportunities, to make deliberate small-scale changes, or to cope with the consequences	Presence of institutionalized mechanisms for learning (e.g., learning-action alliances; presence of strong knowledge institutes) Evidence of the capability of actors related to institutions and local communities to adopt new approaches and perspectives (e.g., implementation of flexible policies)	Folke et al. 2005, 2010, Millennium Ecosystem Assessment 2006, Pahl-Wostl et al. 2007, Mostert et al. 2008, Raadgever et al. 2008, Gupta et al. 2010

Wostl et al. 2007, Mostert et al. 2008, Raadgever et al. 2008). Although the capacities to resist and to absorb and recover can conceptually be linked to specific types of FRM strategies, it does not seem justified to draw a similar link for capacity to transform and adapt. Table 2 summarizes our conceptualization of the three capacities of flood resilience and presents preliminary indicators that may help in determining to what extent each capacity is present in a specific country, as well as an overview of the main sources consulted.

Balancing the desired capacities

Although the conceptual boundaries between the three capacities are not cast in stone, we argue that they represent different aspects and understandings of resilience, each with presumably different outcomes in terms of an eventual decrease of the number of floods, casualties, or amount of damage sustained. An empirical question concerns how the different desired capacities would relate to one another. Theoretically, one could argue that the desired outcome of more flood resilient countries is better reached in cases in which all three capacities are present in a country to a large extent. The question comes to the fore, however, of whether this is possible, because there could be potential trade-offs between the capacities, e.g., a high capacity to resist may limit the capacity to absorb and recover (Liao 2012). At the same time, capacity to transform and adapt may be a capacity in itself but also to some extent a precondition for both other capacities. This indicates the need for an explorative, interpretative analysis in which countries' degree of implementation of FRM strategies (research question ii); their achievements in terms of whether or not, and to what extent, the three capacities are present (research question iii), and the overlaps and (potentially causal) links between the two are carefully considered.

METHODS

The empirical material discussed in this paper has been collected in the framework of a research project funded by the European Commission called STAR-FLOOD (http://www.starflood.eu/). Within this project, policy analysts and legal scholars in Belgium, England, France, the Netherlands, Poland, and Sweden conducted empirical analyses and evaluations of flood risk governance in their country, both at the national level and at the level of three case studies focusing on specific urban areas that were used to illustrate and further explore developments at the national level. As part of this research, an explorative assessment was made of whether or not, and to what extent, the three capacities discussed in the previous section were present. Data collection methods applied in all countries are desk research (analysis of policy documents, legal texts, case law, literature); semistructured interviews (70 in Belgium, 61 in England, 64 in France, 45 in the Netherlands, 54 in Poland, and 19 in Sweden), and at least one workshop with stakeholders in each country (Alexander et al. 2016*b*, Ek et al. 2016, Kaufmann et al. 2016, Larrue et al. 2016, Matczak et al. 2016, Mees et al. 2016). The topics about which data were collected included factual information about the presence and relative importance of flood risk management strategies, their institutional embedding in flood risk governance arrangements, and actors' information and opinions regarding various aspects of flood risk governance in their country. Next to this, there were many occasions on which the comparison of strategies, arrangements, and resilience capacities was discussed with all six country teams.

Because of this breadth of the paper's empirical knowledge base and our ambition to provide an overview at a relatively high level of abstraction, it is necessary to present the findings in a condensed way. The next section on the degree to which the analyzed countries have managed to implement a diverse and aligned set of FRM strategies focuses on aggregated findings regarding the presence and relative importance of strategies. A detailed elaboration on how strategies have been institutionalized in countries and how this has developed over time is presented in six publicly available national project reports (Alexander et al. 2016*b*, Ek et al. 2016, Kaufmann et al. 2016, Larrue et al. 2016, Matczak et al. 2016, Mees et al. 2016).

Table 3. Characterizing flood risks in the six countries.

	Population affected by a 100-year flood, considering presence of protection (absolute, x1000 pp. and relative in %)	Population affected by a 100-year flood, considering no protection present (absolute, x1000 pp. and relative in %)	Expected damage of a 100-year flood, considering presence of protection (M€, and in % of GDP)	Expected damage of a 100-year flood, considering no protection present (M€, and in % of GDP)
Belgium	0 (0.0)	513 (4.9)	0 (0.0)	7038 (2.3)
UK[†]	45 (0.1)	1163 (1.9)	1379 (0.1)	43,524 (2.4)
France	268 (0.4)	3265 (5.2)	11,316 (0.7)	67,143 (3.9)
Netherlands	0 (0.0)	2864 (17.5)	0 (0.0)	36,275 (6.7)
Poland	1009 (2.6)	1842 (4.8)	16,806 (3.2)	28,880 (5.6)
Sweden	250 (2.8)	306 (3.4)	13,901 (4.9)	17,455 (6.1)

Source: The figures in the four columns depicting potential impacts of a 100-year flood were taken from Alfieri et al. 2015:204. UK
[†]Alfieri et al. did not provide figures on potential impacts for England specifically, therefore, the table is depicting figures for the United Kingdom as a whole.

FLOOD RISKS AND FLOOD RISK MANAGEMENT STRATEGIES IN SIX COUNTRIES

Nature and extent of flood risks

All countries in the comparison are at risk of pluvial and fluvial flooding since 1950 (see also Driessen et al. 2016). Tidal flooding and flooding due to high waves has occurred only in Belgium, England and the Netherlands, whereas Sweden also knows flood risks due to snowmelt and ice plugs. Flash floods have occurred in England, France, Germany and Poland. All countries have a recent historical record of flooding, but as the figures on casualties and economic losses show, the impact of these floods was much more substantial for England, France and Poland as opposed to Belgium, the Netherlands and Sweden (for details, see Driessen et al. 2016, based on Barredo 2007, Kundzewicz 2012, Kundzewicz et al. 2013, 2017, Alfieri et al. 2015).

Table 3 shows the consequences of a potential 100-year flood as projected by Alfieri et al. (2015). Despite the limitations and uncertainties of using broad scale risk modeling for comparative purposes, these figures provide insight into the relative differences between countries. Considering the current level of flood protection, Alfieri et al.'s figures suggest that Belgium and the Netherlands are very safe while all other countries could suffer relatively large (UK, France, Sweden) to very large (Poland) consequences in terms of both casualties and losses. Comparing these figures with the expected consequences in the absence of flood protection may provide a crude indicator of the countries' current reliance on flood defense measures. Table 3 shows that all countries are vulnerable in cases where flood defenses would fail, but while the difference between the figures with and without protection is relatively modest in Sweden, the difference is dramatic for the Netherlands with 17.5% of the population potentially affected and an estimated economic loss of 6.7% of GDP (see also: http://collections.unu.edu/eserv/UNU:5763/WorldRiskReport2016_small.pdf).

Figures like these only provide a crude indicator of the intercountry differences. Moreover, they neglect that some countries have substantial intra-country differences while others seem to be more homogeneous in terms of flood risk. In England and to a lesser extent France, there is a large variation of type and severity of flood risks within the country (Alexander et al. 2016*b*, Larrue et al. 2016). Although the Netherlands knows intra-country differences in terms of, e.g., flood depths and the speed of onset of flooding, the country is much more homogeneous in that the magnitude of flooding if it occurs will be very high in general, while 59% of the country is susceptible to flooding and 26% of the land is situated below sea level (Kaufmann et al. 2016). In Sweden, on the other hand, flood risks are very local in nature, with some cities being highly susceptible, e.g., Gothenburg or Kristianstad, whereas other cities are not (Ek et al. 2016). In Poland, almost half of the municipalities are endangered. Urbanization and urban sprawl processes with increases in the amount of impermeable surface are expected to elevate the risk of flash floods (Matczak et al. 2016). A specific factor for Belgium is its comparatively very high degree of land sealing (Mees et al. 2016). It seems safe to assume that all countries will face a significant increase in flood risk due to climate change, although this has been less clearly identified in France and Poland as opposed to the other countries (Larrue et al. 2016, Matczak et al. 2016). In northern France, the impact of climate change on floods will be similar to the northern countries, whereas in the center and the south, the impact is less clear.

Comparison of the implementation and alignment of flood risk management strategies in six countries

All six countries addressed have, to different degrees, all five strategies in their flood risk policies, but their relative importance and manner of implementation differs. Appendix 1 discusses each of the six countries and the extent to which measures related to specific strategies have been implemented and linked together.

As the appendix shows, Belgium, France, the Netherlands, and Poland have a predominant focus on flood defense with an emerging broadening toward other strategies (predominantly prevention and mitigation in Belgium, mitigation in the Netherlands, prevention in France, and preparation in Poland). England, at the other extreme, has a broad portfolio of strategies in place. Sweden has a very specific focus on local measures, among other things, because of the relatively low and highly dispersed flood risks in the country, the absence of national flood policies and the large degree to which responsibilities have been attributed to local governments.

All countries report "fragmentation" as one of the key features of FRM, although the countries differ in what is fragmented, why, and whether it is seen as a problem. For instance, in the

Table 4. Capacity to resist in the six evaluated countries.

Country	Capacity to resist	
Belgium	(+)	Relatively high, with the establishment of advanced flood defense works.
	(-)	Slow implementation of water retention in urban areas.
England	(+)	Long tradition of flood defense infrastructure, especially in cases of high flood risks, but without the dominance that is visible in other countries.
	(+)	Flood storage/retention basins are in place.
France	(+)	Long tradition of flood defense.
	(+-)	Maintenance is lacking in places.
	(-)	Unclarity regarding maintenance responsibilities (which is however being improved).
	(+/-)	Slow implementation of water retention in urban areas.
The Netherlands	(+)	Solid and effective defences. High waters in 1993, 1995, and 2012 were successfully withstood.
	(+)	Secure resource flow from taxes raised by the national government and regional water authorities.
	(+)	Solid knowledge infrastructure.
	(-)	Maintenance somewhat lacking.
	(+/-)	Slow implementation of water retention in urban areas is taking place.
Poland	(-)	Despite major dike failures, structural defenses continue to play a dominant role. The principal lesson from the floods was that structural defenses should be strengthened.
	(-)	Lack of resources and high dependency on World Bank and EU funds.
Sweden	(+)	Flexible application of flood defense infrastructures in some municipalities.
	(+)	Temporary small-scale defenses are used in many situations.
	(-)	Lack of resources in some municipalities.

Netherlands, there is fragmentation between water system management, spatial planning, and flood preparation. In Sweden flood policies are scattered over many societal domains and no discernible policy domain can be distinguished. In England fragmentation and many subdomains have emerged as flood risk governance has evolved in a piecemeal manner. In Belgium the fragmentation lies mainly in the administrative complexity of the country, with some responsibilities residing at the federal level, and some at the level of the regions (and within the regions there are many different water managers for different types of watercourses). Whereas in Poland there is large fragmentation between different institutions (and different sectors) responsible for the individual strategies, and a complex configuration of actors, while the rules of the game have been dramatically changing in the last 25 years, considerably more than in other countries studied. In France, several efforts at integration are undertaken by various governmental actors at the local level through PAPI (local flood action plans) and to some extent flood risk management plans.

Fragmentation is a logical consequence of a diversification of strategies and not inherently negative. However, the risk arises that strategies are insufficiently tailored toward one another and that a lack of coordination arises. For instance, disaster management may develop autonomously from water management/flood protection, or recovery mechanisms (compensation schemes/insurances) may be implemented while insufficiently taking into account whether or not they incentivize preventative measures. To overcome this fragmentation, bridging mechanisms are being developed in all researched countries, some being organizations, bridging concepts, policy instruments, financial instruments, or tools that facilitate integration between public and private actors, policy levels, and policy sectors.

Strategies' desirability, necessity, and technical feasibility for different types of flood risks

The question arises about whether the implementation of all five strategies is needed, feasible, and desirable in all six countries. In all countries there is, to some extent, a logical connection between the nature and extent of flood risks and the strategies implemented. For instance, given that flood risks are highly diverse in England, the implementation of a balanced portfolio of strategies seems to be a logical response. On the other hand, large parts of the Netherlands would not been habitable in the absence of strong and reliable flood defenses, partly explaining a predominant focus on flood defense. It would, however, be too simple to assume a deterministic view in which certain types of risks prescribe or lead to certain responses in terms of strategies and measures. For one, we already see that even in countries with a dominant focus on flood defense like the Netherlands and Poland, a diversification of strategies has entered policy agendas and that concrete efforts are discernable. Second, choosing an appropriate response to flood risks will always involve normative choices of how much risk reduction should be achieved, at what cost, and whether risk should predominantly be reduced by focusing on reducing the probability or the consequences of flood risks. But presumably different normative choices will have different outcomes in terms of the degree and type of flood resilience achieved.

EVALUATING COUNTRIES' FLOOD RESILIENCE

Capacity to resist

As is illustrated in Table 4, the nature and extent of the capacity to resist floods has been found to differ between the six countries. The Netherlands, Belgium, and France can be characterized by a dominant focus on defenses, whose functioning can be reported as effective. A similar dominance is present in Poland, but here the effectiveness of flood defenses is lacking; most flood damage during the disastrous 1997 and 2010 floods occurred in areas protected by dikes. In Sweden and England, there is a more holistic approach to FRM in which resistance measures are considered vis-à-vis other types of measures. Although defense was found to be dominant and effective both in the Netherlands and France, lack of maintenance has been reported, to some degree for the Netherlands and to a serious degree for France (Kaufmann et al. 2016, Larrue et al. 2016). In England, in many cases of high flood risk the capacity to resist is present, but flood defenses are usually

Table 5. Capacity to absorb and recover in the six evaluated countries.

Country	Capacity to absorb and recover	
Belgium	(+)	More space for water provided in past 15 years.
	(+)	Water assessment, signal areas, and other instruments help to increase (at least not to decrease) capacity to absorb.
	(+)	The development in terms of communication, warning, evacuation: progress is noticeable.
	(+/-)	Crisis management system is being further developed.
	(+)	Flood insurance is based on mandatory inclusion of flood issues in the fire insurance.
	(-)	Ongoing increase in the amount of hardened surface.
England	(+)	Sophisticated flood warning and emergency response is in place.
	(+)	Insurance system with high market penetration is in place.
	(+)	Efforts to raise community awareness and increased preparedness.
France	(+)	All main urban areas are protected by retention basins, located far from these cities and able to absorb most of the small and average floods.
	(+)	Crisis management system is in place.
	(+)	National CAT-NAT compensation scheme, covering losses after a flood has occurred, is nation-wide and compulsory.
The Netherlands	(+)	Natural hydrological regimes are being reconstructed via redeveloping space for the river and for smaller water courses and other measures. A large nationwide Room for the River program has recently been finalized.
	(+)	Good forecasting and warning in place.
	(+/-)	Growing attention to spatial planning and crisis management system (multilayered safety approach).
	(+/-)	There is a public disaster fund available providing for compensation and recovery.
	(+)	A new multilayered safety approach complementing flood defence has been developed.
Poland	(+)	Crisis management system has been developed and coordination when a flood occurs has improved.
	(+/-)	There is a private insurance system in place, but market penetration is low (-).
	(-)	Room for the River measures are discussed in policy documents but implemented to a limited extent.
	(-)	Ongoing increase in the amount of sealed surface.
	(-)	Retention measures are scarce because they are not economically viable.
Sweden	(+)	Well-functioning emergency management (also for other purposes).
	(+/-)	Flood prevention and mitigation measures are developing.
	(+)	Insurance system with high market penetration is in place.

considered as part of a portfolio of FRM strategies, ensuring a holistic approach to FRM (Alexander et al. 2016*b*). Similarly, Sweden deals flexibly with flood risks with examples of flood defense infrastructures in some municipalities, while temporary small-scale defenses are used in many situations. Sweden differs from the other evaluated countries in that flood risks are relatively low and highly dispersed, so the need to build resistance through flood defenses is dependent on the local situation and urgency (Ek et al. 2016).

Capacity to absorb and recover

The six countries vary in terms of their capacity to absorb and recover (Table 5). The Netherlands and Poland rely significantly on the defense strategy, thus resistance is the main focus. In the Netherlands, more natural ways of defense ("foreshores," room for the rivers) have been developed, and mitigation and preparation measures complement the dominant defense strategy. These measures are receiving increasing attention in the Delta Program, a national program on flood management and fresh water supply based on the Water Act, through the multilayered safety approach. Measures to store water, both through upstream retention and urban drainage, are being implemented in France, the Netherlands, England, and especially in Belgium. Thus, in the latter country, an increase in the amount of sealed surface is being counterbalanced, whereas such development is barely counterbalanced in Poland. Although England has a sophisticated flood warning and crisis management system and Poland has made significant improvement in terms of this flood preparation, this strategy can be said to require further development in France. In the case of the Netherlands, the flood warning system also seems to work well; however, it is more difficult to assess because of limited recent hands-on experience with crisis management.

The capacity to recover requires resources to be employed after a disturbance. It comprises financial resources as well as material ones and institutional ability. The main systems are public disaster funds and insurance systems. Such systems are in place in all countries, although they are governed in different ways, e.g., through public or private mechanisms. In terms of available resources in relation to flood risk recovery, France is well established, whereas Poland and the Netherlands seem to be at risk.

Capacity to transform and adapt

Flood risk governance in the investigated countries differs in its capacity to transform and adapt. In all the countries we witnessed some changes in recent decades, indicating that all are transformative and adaptive to some extent. All the countries have stronger and weaker points though, as highlighted in Table 6. England seems to have more strengths compared to the other countries: with relatively well-developed flood awareness of citizens, a strong learning culture, and the presence of local resilience fora which enable flexible, tailor-made solutions. Hence, adaptive capacity in England can be ranked as high. The built-in flexibility also provides the English system with a relatively high transformability. Other countries show a more mixed view in terms of their strengths and weaknesses and hence their adaptive capacity can be assessed as moderate. Belgium, France, Sweden, and especially the Netherlands report a relatively low flood

Table 6. Capacity to transform and adapt in the six evaluated countries.

Country	Capacity to adapt	
Belgium	(+)	Social learning between water managers and spatial planners through Committee on Integrated Water Management.
	(+)	Flexibility and creativity of public servants who are used to consecutive state reforms and the fluid composition of government coalitions.
	(+)	Relatively open governance system, providing many entry points for change.
	(-)	Expertise remains fragmented.
	(-)	Limited flood awareness of citizens, but improving through legal instruments (duty to inform, water assessment).
England	(+)	Established cultures of institutional learning are present, adaptive management approaches are pursued and opportunities for innovation are present.
	(+)	Community-scale adaptation initiatives exist.
	(+)	Climate change and future uncertainties are integrated in flood risk assessment, planning, and strategy formation.
	(+)	Environment Agency/Defra research and development program stimulating innovation and uptake of research in practice.
	(+)	Local Resilience Fora (2005) facilitating knowledge exchange and institutional learning for future response
	(+)	Dominance of incremental change dominated by policy (rather than requiring legislation) providing institutional flexibility and leaving the scope for adaptation.
France	(+)	Strong infrastructure for research and innovation in place and a lively debate of flood policy.
	(+)	Climate change induces new plans and measures, but not fully related to floods.
	(+)	Integrated flood risk management tool (PAPI) addresses the need for flexible, tailor-made, solutions in a hitherto highly centralized country (some successful examples of these have been documented, e.g., in Nice).
	(+)	Some local governments regrouped into basin water boards implementing innovative tailor-made solutions to integrate local development and adaptation to floods.
	(+)	Wider ongoing decentralization process provides entry points for deliberate change.
	(-)	Limited awareness/involvement of citizens.
The Netherlands	(+)	Periodic risk analysis, testing and, if needed, strengthening of flood defences takes place.
	(+)	Much knowledge development on improving flood safety, including new knowledge about hydraulic conditions, strength of flood defences and consequences of a flood.
	(+)	New information is quickly taken up in law, testing and design guidelines and in dike improvements.
	(+)	Formal inclusion of the duty for municipalities and water authorities to cooperate in the Water Act and by the legal provisions that are also regarded as formal plans based on the Spatial Planning Act.
	(+)	Preflood compensation regimes based on the Water Act and the Spatial Planning Act have been streamlined.
	(+)	Large-scale national program on water safety and fresh water supply is in place (National Water Plan including Delta Programme, elaborated in projects "Hoogwater beschermingsprogramma").
	(+)	Independent taxes from regional water authorities provide for sufficient financial resources and Delta fund guarantees long-term financing of FRM measures.
	(-)	Transformability is hampered because of relative dominance of flood defense actors.
	(-)	Lack of awareness of small communities, citizens, and businesses.
Poland	(+)	Quick and positive changes were introduced between the floods of 1997 and of 2010 although the shift from an old to a modified water law has not yet been completed, despite many changes.
	(+)	The legal framework establishing a crisis management system was developed, passing multiple new laws.
	(+/-)	Locally designed and flexible crisis management teams are present varying, however, in resource availability.
	(-)	Focus on the short term (time scale of elected politicians) and single-strategy is present.
	(-)	Limited reflection on the appropriateness of goals that are strived for is taking place.
Sweden	(+)	Developed and systematic multirisk analysis, carried out periodically by all public authorities, including municipalities, is present.
	(-)	Limited experience with larger floods is likely to be a limiting factor for the development of knowledge and innovations as well as for the citizens' awareness of flood risk.
	(-)	The strong role for local governments in Sweden allows for a high degree of local flexibility (+) but may hamper intermunicipal coordination and learning.
	(-)	Uneven distribution of resources across municipalities.
	(-)	The relatively passive role of the national level.

awareness of citizens, whereas flood awareness in Poland, because of catastrophic floods in 1997 and 2010, is relatively high. Established systems for learning are in place in the Netherlands, France, and to a lesser extent Belgium. Possibilities for applying local tailor-made solutions have been reported for France, the Netherlands, Poland, and Sweden. In Sweden and the Netherlands, established systems for risk analysis are in place; in the Netherlands the focus is on the maintenance of flood defences; and in Sweden focus is on multiple risks, including floods. The strengths of the Belgian and Polish system are that civil servants and others have been reported to adapt flexibly to quickly changing legal systems and political constellations. For Belgium, fragmentation of relevant expertise has been reported.

In Belgium and France, the moderate adaptive capacity is accompanied by a comparatively high transformability. Belgium has a relatively open governance system with many entry points for change. In France, the ongoing systemic decentralization process was also found to provide entry points for change. Sweden provides a more mixed picture in terms of transformability. Because there is no overall FRGA and flood policies are scattered

across many domains, there are many opportunities at the local scale to initiate deliberate change, leading to some inherent flexibility, but there is also the risk of actors reinventing the wheel. Transformability in the Netherlands and Poland is comparatively low. In Poland, there was change (response strategy strengthened) but still a strong defense-orientated paradigm remained in place. Moreover, the change was not deliberate but it was a response to an external event. Although the Netherlands is a frontrunner in developing flood relevant knowledge, it is also a country that shows both a relative dominance of the actors related to flood defense and a relatively limited consideration of flood risks by some other actors, such as those related to spatial planning. The dominant actors have been shown to incorporate new discourses and developments, e.g., ecological turn in 1980s and room for the river in 1990s and beyond, without changing fundamentally, which may hamper transformability in the long term.

CONCLUSION, DISCUSSION, AND REFLECTION

Conclusion

Our aim was to contribute to resilience and flood risk governance literature by scrutinizing the assumption that a diversification of FRM strategies is the way forward. Flood risk governance approaches in six countries were compared, and the countries' flood resilience in terms of their capacity to resist, capacity to absorb and recover, and capacity to transform and adapt was evaluated.

Although England, from a national perspective, has the most diversified set of strategies in operation, other countries show a relative dominance of specific strategies. In France, we found a strong discursive emphasis on prevention that is keeping people away from water through proactive spatial planning, which seems to be at odds with its de facto emphasis on the implementation of flood defense works. There is a strong focus on defense in the Netherlands; on flood preparation in Sweden; on defense and mitigation in Belgium; and on defense and preparation in Poland. All countries report "fragmentation" as one of the key problems of FRM, although the countries differ in what is fragmented and why. For instance, in Belgium, Poland, and England, fragmentation is illustrated by institutional complexity and the presence of a diverse array of strategies, whereas, e.g., in the Netherlands, the fragmentation is related to the relative absence in FRM of flood-relevant policy domains other than water management (e.g., spatial planning and a weaker role in emergency management), a fragmentation that is only very slowly being overcome.

As we have shown, each country has specific strengths and weaknesses in terms of resilience. England is strong on all three capacities, but in particular on the capacity to transform and adapt. The Netherlands and to a lesser extent Belgium have a strong capacity to resist, and Belgium, England, and France a very high capacity to absorb and recover. In Poland the presence of all three capacities seems to be low to medium-high, while in Sweden it is medium to high in individual categories. In Poland progress has been made in capacity to transform and adapt, but more in terms of adapting (by establishing the crisis management system) than in terms of transforming (transformability of the system was shown to be very low). With some risk of oversimplification, it seems that the implementation of a more diverse portfolio of strategies contributes to a higher capacity to absorb and to adapt, obviously provided that the strategies have been implemented effectively.

Discussion

The question comes to the fore of what this teaches us about the link between having a diversified and aligned set of strategies in place and resilience. This question cannot be answered in a straightforward way, but can be approached from at least two perspectives.

A first perspective, to which, e.g., Liao (2012) would probably agree, is that diversification of FRM strategies is indeed necessary to achieve resilience. Reliance only on flood defense and, seemingly associated, increasing capacity to resist is undesirable when taking into account current and potential future flood risks in times of urbanization and climate change (Holling and Meffe 1996, Kundzewicz and Takeuchi 1999, Liao 2012). An approach solely reliant on resistance may not be capable of adequately addressing these risks while at the same time there might be failure of the infrastructure or a flood above design standards. Seen from this perspective, a country like the Netherlands is taking a significant risk because the actual consequences of floods would be dramatic (high economic damage and many casualties). Although part of the risk taken is the result of choices made in the past combined with inescapable physical circumstances, we have also found that, for example, in current planning decisions, flood risk prevention has a relatively low priority (Hegger et al. 2014). Put in other words, perfect, absolute, flood resistance is not possible. A system may withstand load, but not without limits. According to a statistical design concept, defenses should withstand a design flood, e.g., 100-year flood, but be ineffective if the actual flood is much higher. Therefore, at least from the first perspective, a more disaster-conscious society needs to be built. The dominating stance should be to seek safe-fail (safe in failure) in addition to unrealistic fail-safe (safe from failure) solutions, (cf. Kundzewicz and Takeuchi 1999).

From a second perspective, which is a potential criticism on the first perspective, diversification does not (necessarily) increase resilience. After all, a retrospective evaluation shows that countries that have more strategies in place and seem to have a high capacity to absorb and recover like England are not the countries with the fewest floods, damages, or casualties. One could even argue that a resilience approach does not explicitly aim to avoid these. The example of England shows that having in place a highly diversified set of FRMSs is in itself not enough to prevent casualties and losses from happening (cf. floods in autumn 2000, summer 2007, and winters 2013/2014, and 2015/2016). In this country, there still seems to be room for improvement in terms of further risk reduction, although this criticism should be viewed in the light of normative viewpoints held in England, in which it has been accepted that not all floods can be prevented while it is intended to resist other (life-threatening) floods. England is considered more resilient to flooding by having this diversification.

The two opposing perspectives on resilience makes it necessary for us to nuance our starting assumption that diversification leads to more resilience. The three capacities imply different rationales and normative starting points for flood risk governance, the choice between which is largely political. As we have shown, there

is no one-to-one relationship between the nature and extent of flood risks, the strategies implemented to deal with these risks, and the resulting achievements in terms of resilience. Second, we found trade-offs between the three capacities, e.g., being resistant seems to lower the possibility to be absorbent. Third, to explain countries' achievements in terms of resilience, the strategies' feasibility in specific physical circumstances and their fit in existing institutional contexts (appropriateness) needs to be taken into account. Bridging mechanisms may be an important way to establish links between strategies.

Reflection

If, as argued above, it is too simple to view diversification of FRM strategies as a panacea for improving flood resilience, what would this imply for practical action? Diversification can be thought to be generally advisable, but it should be implemented in a country-specific way. For instance, in the Netherlands, it currently means the establishment of back-up strategies; and in England, it denotes further tailoring of the existing, already balanced, portfolio of strategies. Sometimes physical/geographical circumstances make some strategies unfeasible, e.g., building flood-proof houses in a deep polder. A distinction should be made between strategies that a country must have and strategies that are nice to have. This distinction to some extent involves normative (political) choices regarding acceptable levels of risks, how these should be dealt with, and by whom (see also Lebel et al. 2006).

In countries with a dominant focus on flood defense, like the Netherlands, Poland, France, and Belgium, the presence of effective flood defense infrastructure is a necessity (must have) and other strategies could be viewed as add-on strategies to reduce residual risks (nice to have) although it should be assessed what the consequences of failure of flood defences would be. In the Netherlands, emergency management would probably do a better job than flood recovery. A country like England with more of a balanced approach to strategies would experience more floods, but through the selected approach would perform better than the Netherlands in response and recovery. For England it is necessary to also have effective bridging mechanisms between the strategies. The dominance of the structural defense system in Poland is nonabated. However, other flood risk reduction strategies are on the rise. In France, the recovery system will not be sufficient in case of major floods (for instance in the Paris region) and it might hamper more preventive or mitigation action. That challenges the elaboration of a more adaptive strategy. The well-developed recovery system in France (and to a lesser extent Belgium), might theoretically contribute to the perverse effect that there is less need to bring prevention and mitigation further.

We hope that this paper has pointed out useful directions for further searches by scholars and practitioners toward more flood resilience. Our comparison undoubtedly shows that there is no single pathway to a universal resilience, even if it is considered in the broadest sense of the word. Flood resilience cannot be conceived of without a sense of institutional and territorial appropriateness.

Responses to this article can be read online at:
http://www.ecologyandsociety.org/issues/responses.php/8854

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Belgium

Belgium faces risks regarding coastal, pluvial and fluvial flooding. While Belgium initially could be said to have a dominant focus on flood defense, in recent years diversification towards flood risk and flood risk prevention (at the level of the regions) and also to preparation and recovery (mainly at the federal level) has taken place. Besides the ongoing diversification of strategies, Belgium's complex institutional setting as a federal state implies that the country has recently put much energy into creating bridging mechanisms between the numerous arrangements and actors (ibid).

Flood risk management in Belgium and, in particular, Flanders is part of integrated water management, based on an integrated Water Act (Flemish Government 2003). Legislation is characterized by general principles such as that water constitutes an element to be taken into account in spatial planning, that water should preferably be kept, stored and finally drained and that water should be given as much space as possible. Since recently, a general regime has existed that ensures that no building activities should take place in flood-prone areas without taking mitigation or compensation measures (Mees *et al.* 2016). Flanders also has a water assessment which relates to plans, programs, and licenses not only with regard to building activities but also to environmental licenses (De Smedt 2004). The system requires that potentially harmful effects on water management should be assessed and if these effects are present, a license should contain provisions to address these negative effects by means of mitigation or compensation measures to be taken. After modifications of the instrument in 2010 and 2013, advice by water authorities has now become mandatory and its scope has been broadened even further to leave more room for water (Mees *et al.* 2016).

A new instrument that bridges several strategies is the so called 'signal areas' which are areas where a contradiction may occur between the interests of the water system and the spatial development perspectives. These areas may play an important role in flood risk management, for example, as they can act as a "sponge" as a result of their natural characteristics. It is a general instrument to protect the available room for water. The consequences of delineating signal areas can be different dependent on what level of flood risks has been assessed. In some cases building activities remain possible but under restrictions while in other cases spatial destinations should be changed. In signal areas the water assessment is more intense and includes more mitigation requirements as well as the obligation to inform property owners and tenants about the flood risks. The relationship between flood risk management and spatial planning is further accompanied by the possibility for expropriation, and by the possibility that a property owner may, in certain cases, demand that the government acquires the property, for example, when the owner is confronted with a delineation of a retention area. Another bridging mechanism can be found in building requirements which aim to avoid rainwater nuisance by requiring a minimum storage capacity of 5,000 liters per property for (uni)family homes unless a green roof has been provided for (Rainwater Regulations 2014; Mees *et al.* 2016). In Belgium, the link between prevention and recovery is made by the inclusion of flood damage in the general fire insurance. This might offer promising opportunities to reinforce the flood risk prevention strategy.

England

Flood risk governance in England can be characterized by a comparatively balanced consideration of flood risks, with similar importance attributed to fluvial, coastal and latterly pluvial flooding (Alexander *et al.* 2016; Hegger *et al.* 2013). This has contributed to a diverse approach to FRM with England having the most diversified set of measures for flood risk management and related governance arrangements among the six countries examined. All strategies distinguished in this paper are in place and most of them have been present for many years. In England, as all five strategies already exist, diversification entails broadening within strategies through the application of new measures and the involvement of new actors and rules. These have led, however, to a degree of fragmentation and although there have been strong efforts to align and bridge between strategies, considerable further effort is still required (Alexander *et al.* 2016). Despite all strategies being present in most situations, the balance between strategies may vary locally depending upon the type and level of flood risk as well as management priorities.

Contrary to Belgium, France and The Netherlands, in England there are no safety standards that formalize the relationship between the several strategies and flood risk management and the financing of defense is primarily based on cost-benefit analysis (Hegger *et al.* 2013). For the preventive strategy, spatial planning is the most important and takes place at the local level; with both application of decision-making and strategic planning (which indicates which areas should be considered for new development) being undertaken by Local Planning Authorities (LPA). English spatial planning legislation is highly fragmented in itself but is based on the premise that spatial planning is mainly a local concern. Flood risks are an important planning consideration which can justify the refusal of planning permission and in practice do so. LPAs are required to produce a Strategic Flood Risk Assessment which is used to inform Local Plans about flood risk concerns when prioritizing areas for future (re)development. The Sequential Test, similar in type to the Dutch and Belgian water assessment, is an instrument that aims to direct new development towards land with lower flood probabilities and this is used as a measure to test the appropriateness of potential development (Alexander *et al.* 2016). If the Sequential Test is not satisfied, it is possible to apply the Exception Test, which permits development in flood risk areas when the safety of a development can be assured and that the "development provides wider sustainability benefits…that outweigh flood risk" (Department of Communities and Local Government 2012; 24). Therefore, the aim is not to preclude all development in flood risk areas, but ensure that development is appropriate, that mitigation measures will be taken and that evacuation is properly addressed and organized (Alexander *et al.* 2016).

FRM strategies in England are bridged by common actors (notably the Environment Agency) who have key responsibilities in all strategies apart from recovery. There is also a long-held and increasing focus on community-level management including awareness-raising which enables individuals to better understand flood risk, adopt any appropriate

(defense and mitigation) measures at an individual or community scale and take preparation actions for future floods.

France

France is facing all types of flood risks: fluvial, pluvial, coastal and flash floods. The country suffered from serious localized floods in the last few years. In France, all strategies are present, but they do not appear very well aligned. However, at a discourse level, prevention plays a very important role in reconfiguring and 'embracing' all other approaches to flooding. A typical example of this is provided by the Action Program for Flood Prevention (PAPI). Prevention is considered the main strategy in terms of social and political legitimacy, but defense dominates in implementation practice (Larrue *et al.* 2016).

Since the 1980s more attention was given to decentralized actors as France has been a strongly centralized state. Since the 1930s, there have been legal possibilities to keep areas free from urban development as part of the prevention strategy. A Flood risk Prevention Plan (PPRi) is formulated by state services in areas under flood risk. There is no integrated flood risk management based on one integrated water act. However, there are plans at basin level (SDAGE and SAGE, "Schéma d'Aménagement et de Gestion des Eaux" and "Schéma Directeur d'Aménagement et de Gestion des Eaux", local water management plans and water management master plans respectively); and a water act at national level which, however, only partially include floods as these are mainly considered through the Natural Risk Act. This might make the coordination between strategies more difficult. Authorities in the field of spatial planning should take some general principles based on national legislation into account, and on PPRi in localities where they exist, although they have a large amount of policy discretion. One of these principles is the obligation that spatial plans should try to reduce the risk of natural disasters, including floods. Furthermore, there is a coordination mechanism between water plans and spatial plans. Another mechanism is the link made theoretically between recovery and prevention strategy: the CatNat system through the National Fund for the Prevention of Major Natural Risks called the Barnier Fund helps to implement prevention devices, and must be related to risk plans. However this relationship is not effective in reality. Another bridging mechanism is related to the fact that when granting licenses in the field of spatial planning, water plans as well as PPRis should be taken into account. A more informal bridging mechanism provides that risk management plans should take land use into account, but there is no formal legal regulation of this mechanism. The most important authority for flood risk management, at local level, is the municipality as it has a general obligation to take care of the safety of its citizens. This means that applications for licenses for developments that may increase flood risks may be refused. There is neither specific legislation that deals with flood risks in relation to spatial planning nor legislation that addresses flood risk mitigation measures. Local guidelines are being developed to fill this gap.

The Netherlands

The Netherlands are faced with risks related to coastal, pluvial and fluvial flooding (Hegger *et al.* 2013). In The Netherlands, the flood defense strategy with probability-reducing measures, such as the construction and maintenance of dikes, is historically predominant, although The Netherlands also have a tradition of specific mitigation measures (Hegger *et al.* 2014, Kaufmann *et al.* 2016). In the last 20 years, consequence-reducing strategies, most notably flood risk mitigation, have become more popular again, even though they are nowadays mostly applied in exceptional cases where the flood defense approach is not seen as efficient or feasible (Van Buuren *et al.* 2014). Flood risk prevention through pro-active spatial planning is hard to realize in a densely populated country where it is difficult to find space for natural solutions, and gets therefore less attention (Hegger *et al.* 2014a), although there are formal rules against building in unembanked areas that are not protected by the primary dikes (Hegger *et al.* 2014, Kaufmann *et al.* 2016).

In The Netherlands, flood risk management is part of integrated water management, based on an integrated Water Act (Van Rijswick and Havekes 2012). Flood risk policy is characterized by general principles such as that water should be leading in spatial planning, that water should preferably be retained, stored and finally drained and that water should be given as much space as possible. The flood defense strategy can be seen as well-developed and also highly institutionalized and legally embedded. Safety standards prescribing the necessary strength of flood defenses have been laid down in the Water Act. The legal embedding of flood defense reflects the idea that water management should follow land use. In recent times, there is more attention for also considering the effects of land use on water management (ibid). In the past 20 years following the (near) floods of 1993 and 1995, several initiatives have been taken and policy documents developed to give spatial planning a stronger role in FRM, including the prohibition of building in the winter bed of rivers; the establishment of a formal 'Room for the River' policy program as well as the establishment of a so-called 'water assessment', an obligatory procedural instrument that enables water managers to advise spatial planners on the effects of new developments on water management, including flood safety (ibid and also Correljé *et al.* 2010; Hegger *et al.* 2014; Kaufmann *et al.* 2016). Experience in practice, however, shows that the effectiveness of the instrument is highly dependent on informal cooperation and willingness to seriously examine flood risks in the field of spatial planning. The same goes for measures in the field of risk mitigation. While the Water Act has a general provision that obliges municipalities and water managers to cooperate in the field of urban water management, for the moment there are no sanctions if this cooperation is insufficient. Formal flood recovery mechanisms are hardly present in The Netherlands (Kaufmann *et al.* 2016; Van Rijswick and Havekes 2012).

Poland

In Poland, the structural defense sub-arrangement, focusing on technical infrastructure, dominates (Matczak *et al.* 2016). However, other sub-arrangements, such as prevention and preparation, are gaining momentum. Dramatic experiences such as the flood events of 1997 and 2010 brought different ways of thinking on how to deal with flood risks,

amongst others in terms of how to organize crisis management and how to prevent environmental harm by constructing flood defenses.

Poland has had several large, destructive, pluvial, fluvial and flash floods in the last decades. The relationship between water management and spatial planning has been dominated by the centralized approach (heritage of the communist system in 1944-1989) in which safety was strongly related to military. After the floods of 1997 a program started with the help from the World Bank and later also the European Union which as a novelty included creating more room for rivers in order to decrease flood risk (Matczak *et al.* 2016). Significant improvements in terms of flood preparation were also made. However, in Poland it is difficult to create societal support for more far-reaching restrictions on spatial development, as they may hamper further economic development that is very much needed in this country with emerging economy. Fragmentation of powers on the national, provincial and municipal levels hampers effective coordination between spatial planning and flood risk management. Spatial planning is mainly a municipal competence, while legislation in the field of water management lies at the national level and planning of defenses is taken care of at the provincial level. Because the shift of powers in the field of spatial planning to the municipal authorities was not accompanied by the necessary shift of financial resources, local authorities still do not pay enough attention to taking the effects of flood risks into account and they have no formal obligations to do so. Besides that, the enforcement of spatial plans is insufficient which leads to further ongoing developments in flood prone areas (ibid).

Sweden

Sweden faces risks regarding fluvial, pluvial and coastal flooding, however risks vary significantly in time and space and the experience of severe floods is limited. Flood risk management in Sweden can be considered diversified; all strategies are implemented to some extent, flood preparation and recovery are however most developed. Due to the variability and unpredictability of flood risks, temporary defenses are more common than permanent defense structures. Flood prevention and mitigation are emerging, these strategies have recently been explicitly incorporated in legislation but this has not necessarily been translated to common practice yet (Ek *et al.* 2016).

There is no distinct national flood policy domain in Sweden as in the other STAR-FLOOD countries, instead actors, rules, resources and discourses related to flood risks are scattered over other policy fields such as e.g. risk and safety and spatial planning. Moreover, flood risk management is highly decentralized; while the national level decides on the legal framework governing flood risk management, the municipal level carries the main responsibility for initiating, financing and implementing different flood risk management strategies. Coordination and bridging is thus likely to be most important at the local level. In spite of the dispersion of flood risk governance across other policy areas, the need for coordination and bridging is, to some extent, reduced by the decentralization of Swedish flood risk management. Building regulations are one example of a legal bridging mechanism between prevention and defense and/or mitigation; these nationally set guidelines come into place and are required for building

permits (granted by the municipality) when new developments are planned in a flood prone area (Ek *et al.* 2016).

Flood risk management is not much linked with water management. Water operations are regulated in the Environmental Code (which covers permanent defense and some of the mitigation measures) and other rules related to flood risks (governing prevention and other mitigation measures) are found in the Planning and Building Act. These two laws are applied in parallel. Sweden chooses an approach that refers to general principles – amongst others in its spatial planning legislation – which have to be taken into account by all authorities in all relevant policy fields. Most important is to take care of a prudent and rational use of natural resources. These general principles have effect as well in planning as in the granting of environmental permits (e.g. for defense).