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Flood Risk Governance and Climate Change Adaptation: an analytical framework

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Inhalt

1. Introduction

1.1 Flood risk management and adaptive management

Large flood events during the 1990s and the extreme flood events that hit several European countries in 2002 caused a major policy change in European flood policies and have led to the emergence of a new policy paradigm: flood risk management (FRM). In order to reduce the flood risks in Europe, the European Union adopted the Flood Risk Management Directive in 2007, which has laid the foundation for integrated flood risk management in all EU member states. The floods directive calls for a new culture of dealing with flood risks based on a catchment-based approach, interdisciplinary planning, the systematic consideration of extreme events, the preference of non-structural measures, and bottom-up elements such as stakeholder participation. Consequently, the directive brings about a paradigm shift and offers the chance to establish a risk culture and a policy change from the prevalent flood protection to a holistic flood risk management (Heintz et al. 2012). Flood policy across Europe is thus shifting from a structural, security-based approach of flood protection towards an integrated, risk-based approach of flood management (Kreibich et al., 2014; Bubeck et al., 2015; Hegger et al., 2013, 2014; Matczak et al., 2015). While the traditional approach was informed by a firm belief in controlling rivers via engineering solutions the nascent paradigm of FRM aims at reducing the severity of and the vulnerability to flooding based on a portfolio of approaches, comprising structural and non-structural measures (Samuels et al. 2006; van Herk, 2015).

In the scholarly literature FRM has been defined as “a comprehensive approach where equal emphasis is placed on mitigation, preparedness, relief and recovery through the involvement of all relevant sectors and stakeholders with the overall goal to reduce flood risks” (ADPC/UNDP 2005). Alternatively, it has been described as “an approach to risk management that embraces all sources, pathways and receptors of risk and considers combinations of structural and non-structural solutions” (Gouldby/Samuels 2005). The definitions point to several key features of the FRM paradigm that can be grouped in four categories:

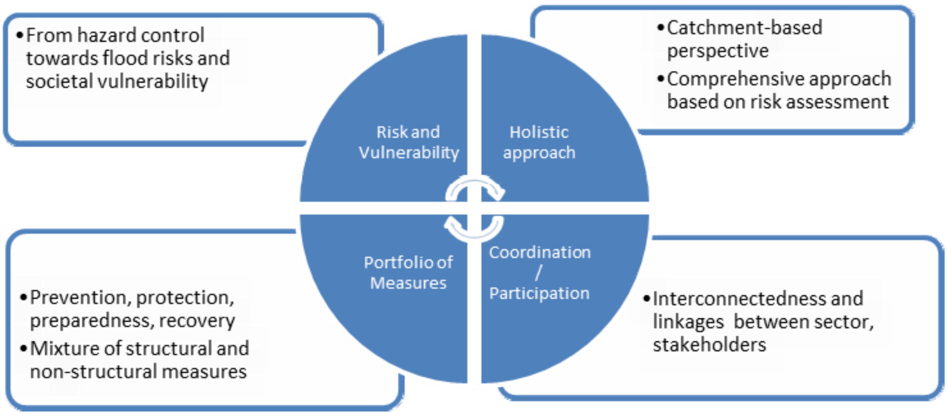


Figure 1: Main features and dimension of integrated flood risk management

Adaption marks a defining feature of the emerging policy paradigm (Klijn et al. 2015; van Herk et al. 2015; Hall and Solomatine 2008). The term is widely used in relation to climate change to mean “the process of adjustment to actual or expected climate and its effects, in order to moderate harm or exploit beneficial opportunities“ (IPCC, 2012). Others use the term with regard to adaptive capacity and mean “adjustments in a system’s behaviour and characteristics that enhance its ability to cope with external stresses” (Brooks, 2003). In this study, we define adaptation as the totality of measures, processes and strategies, which are implemented in flood policymaking to reduce the risk of flooding in an ever-changing and uncertain risk environment. We thus build on the notion of flood risk management being "a continuous process of adaptive management" (Hall and Solomatine 2008) which involves the anticipatory consideration of the ways in which flooding may change in the future.

1.2 Key aspects of the analytical framework

As illustrated in Figure 2, adaptive flood policymaking is **problem-orientated.** The paradigm change in flood policy has introduced a risk-oriented, dynamic perspective which acknowledges that both aspects of risk – hazard and vulnerability – are non-stationary, and that flood risk is a "dynamic entity" (Merz et al. 2010). Climate change and settlement development represent potential drivers of flood risk (Merz et al. 20102; Di Baldassarre et al., 2013). Climate-change induced effects on components of the hydrological cycle are likely to affect the frequency and intensity of future flood hazards. Land use change and land development in river basins on the other hand represent major factors in increasing flood damages and vulnerability.
Future changes in flood risk are subject to different forms of uncertainties. On the one they are characterised by stochastic uncertainty (Helton, 1994) because the system/process under consideration can behave in different ways or is valued differently; i.e. quantities are inherently variable over time, space or populations (van Asselt & Rotmans 2002; Apel et al. 2004). On the other hand, the extent to which climate change or land use change constitute drivers of future flood risk is subject to high knowledge or epistemic uncertainty which results from incomplete knowledge and is "related to our ability to understand, measure and describe the system under study" (Apel et al. 2004).

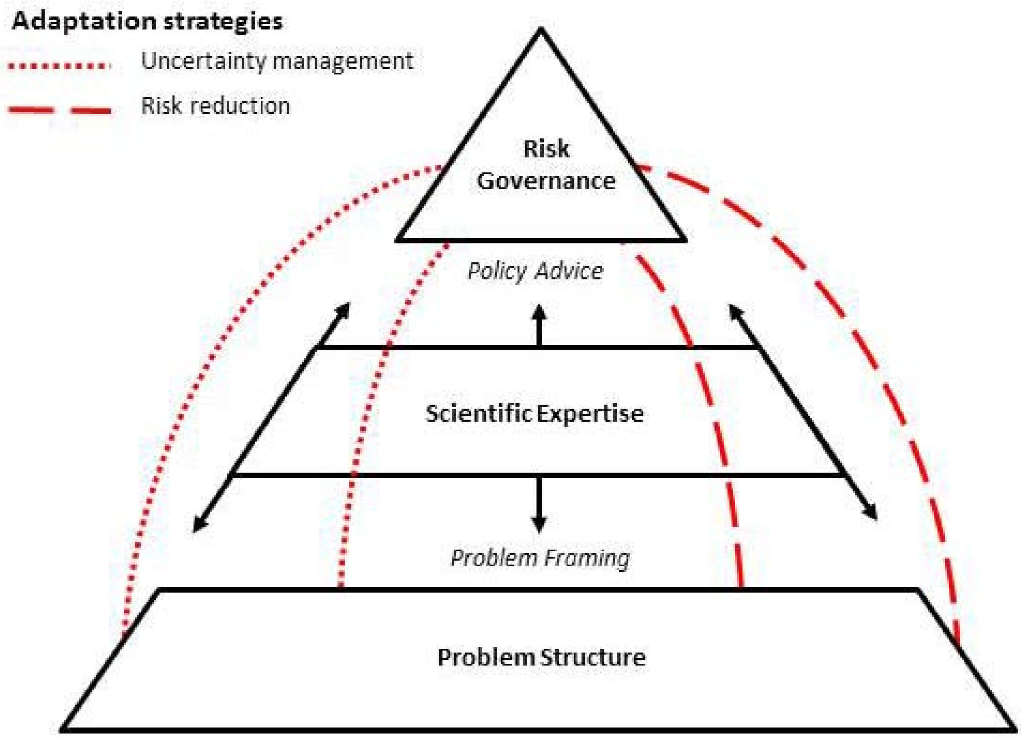


Figure 2: Adaptation strategies of integrated flood risk management

Scientific expertise assumes a central role in the nascent policy paradigm. Scientific assessments provide the knowledge base for framing the underlying problematic of spatio-temporal flood risk dynamics. However, due to the considerable inherent and epistemic uncertainties concerning the system under study, scientific findings (especially with regard to future developments) are often characterised by i) low confidence levels on a regional/local scale (cf. Blöschl 2011), ii) limited temporal validity due to rapid progress in data availability and data processing (cf. Kundzewicz 2015) and a lack of consensus within the scientific community (cf. APCC 2014). Nevertheless, there is a specific demand for scientific policy advice in flood policy making as scientific expertise is generally assumed to provide a strong basis for evidence-based flood management decisions. In order to implement risk reduction measures, which target the individual constituents of flood risk change, it is important to ensure the transferability of scientific results into the policy domain (and vice-versa the development of research agendas based on policy experiences and knowledge needs) and to organise interactions between science and policy (the so-called science-policy-interface).

Although scientific expertise is generally considered to provide support for the development of flood policy solutions under conditions of uncertainty, flood risk management is policymaking after all – and therefore to some extent not only science-driven. It is pursued within flood risk governance arrangements, existing legal frameworks which regulate management practices, and competing interests, e.g. between flood protection and settlement development. The different actors, discourses, rules and resources that shape the formulation and implementation of flood risk management need to be considered to understand the implementation of adaptation strategies, both in the sense of risk reduction and in the sense of uncertainty management.

Strategies of risk reduction can aim at hazard-reduction and/or vulnerability-reduction by employing a set of structural and non-structural measures. As illustrated in Figure 2, these risk reduction strategies may or may not build on scientific assessments (”problem framing”) or be in line with scientific recommendations (“policy advice”).

Strategies of uncertainty management address how policymaking proceeds in the face of uncertainty. They can generally be distinguished in risk-based approaches or adaptive management approaches. As with risk reduction strategies, uncertainty management strategies are often developed on the basis of scientific findings. Policy making may however also be well aware of scientific uncertainties but still opt to assume a proactive stance and base policy decisions on the precautionary principle, which “states that scientific uncertainty does not justify inaction with respect to environmental risks” (Trouwborst 2002:402).

In the following sections we provide more details on all key aspects of the Flood-Adapt project illustrated in figure 2, i.e. on the problem structure and scientific knowledge base (section 2), on the science-policy-interface and the organisation of policy advice (section 3) on flood risk governance and adaptation strategies (section 4) as well as on the comparative conclusions for the cross-case analysis (section 5).

2. Problem structure and scientific knowledge base

Flood risk can be defined as the combination of the probability of a flood event and its potential adverse consequences (UNISDR 2009). As both aspects of risk – hazard and vulnerability – are non-stationary (see Figure 3), flood risk is a “dynamic entity” (Merz et al. 2010). This changeable characteristic of flood risk is emphasized in the EU flood directive (2007/60/EC), which specifies that “…human activities (such as increasing human settlements and economic assets in floodplains…) and climate change contribute to an increase in the likelihood and adverse impacts of flood events” (EU 2007).

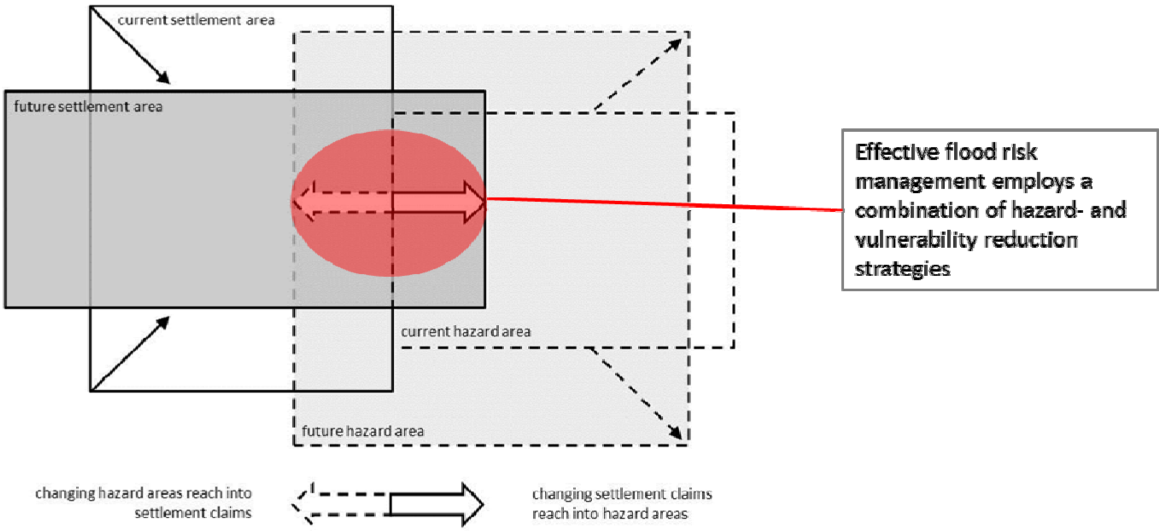


Figure 3: Spatio-temporal dynamics of flood risk and scope of adaptive flood risk management (Source: adapted from BAFU, 2005).

A key indicator for the spatio-temporal dynamics of flood risk is the observed increase in flood damages over the last decades (Barredo 2009; Kreft 2011; UNISDR 2011). This increase can be attributed with certainty to socio-economic drivers such as settlement growth near rivers (see the changing settlement area in Figure 2). There is a general consensus that land development in floodplains has and will continue to have an immediate effect on flood risk changes.

Concerning the influence of climate change on flood hazard (see the changing hazard area in Figure 2) and its role as a potential driver of flood risk, empirical findings are less clear. The results of climate models are uncertain regarding the prediction of future changes in frequency and magnitude of floods (Kundzewicz 2015). Previous studies based on global models and scenario analysis predicted an increase of frequency of floods frequencies for large parts of Europe (Dunkers and Feyen, 2008; Hirabayashi et al., 2008; Kundzewicz et al, 2010; Lehner et al. 2006). More recent studies by the same authors, however, present dramatically different flood projections and conclude that the frequency of 100-year floods and 30-year floods will decrease over most parts of Europe (Kundzewicz, 2015). The recent projections by Hirabayashi et al. (2013) indicate that flood frequency will decrease in much of Northern, Central, and Southern Europe. Only for the Northwestern part of Europe (United Kingdom, Northern France, and Benelux), prevailing increases in flood frequency is projected for a 100-year flood. The projection of Dankers et al. (2014) shows an increase in the frequency of 30-year floods is likely to occur in even a smaller part of Europe (only UK).

While the non-stationarity of flood risk is widely acknowledged, the extent to which land use change and climate change respectively impact current and future levels of flood risk is subject to considerable uncertainty and shows strong regional differences. From the preliminary literature review we can conclude with regard to land use change that settlement and socio-economic growth in flood plains presents with high confidence a major driver of flood risk (high impact, low uncertainty). However, due to differences in e.g. both the supply and the demand for building land the extent of the land use-driven impacts on flood risk varies strongly (high variability). Concerning climate change a preliminary overview of empirical findings indicates that the impacts on past and future changes in flood frequency and magnitude (for Europe in general and for the Alpine region in particular) differ starkly between regions (high variability), while the extent of the impact on flood risk is generally considered lower than that of land use change (moderate impact) and the scientific confidence of findings (especially concerning future changes) is low (high uncertainty). In the Flood-Adapt project we are interested how scientists and policymakers deal with these challenges.

Main research questions:

- What is the state of scientific knowledge on the linkage between climate change, land use change and the spatio-temporal dynamics of flood risk in Austria, Switzerland and Germany?
- What is the degree of confidence, certainty and geographical variability of the scientific findings concerning the respective drivers of flood risk?
- Is there consensus or disagreement on the expected future changes in flood risk?
- Did scientific assessments change in recent years? If yes, in how far?
- How do policy makers perceive the problem, i.e. the linkage between climate change, land use change and the spatio-temporal dynamics of flood risk in Austria, Switzerland and Germany?
- To what extent are policy makers' perceptions based on scientific studies?
- Is there consensus or disagreement regarding the perception of the problem structure between scientists and policymakers?

Method:

- Literature review (peer reviewed publications, studies and assessments), with a particular focus on Austria, Germany and Switzerland
- *Semi-structured interviews with policymakers and scientists (see Annex II)*

3. Science-policy-interface: the organisation of policy advice in flood risk management

Both the scientific and decision-making aspects of adaptive flood risk management are highly complex. From a scientific and engineering perspective, it is often assumed that adaptation policymaking (just) requires more accurate and detailed predictions about future changes. However, social science analyses increasingly challenge the assumption of a knowledge gap that just has to be closed and the associated linear model of upstream science feeding into downstream policy decision-making (Demeritt, 2006; Dilling and Lemos, 2011; Kirchhoff et al., 2013; Kuklicke and Demeritt, 2016: 56). While scientific models ideally account for potential future dynamics in flood risk resulting from climate change or settlement growth, decision-makers have to consider a host of flood management options and thus face a significantly enlarged decision scope. In light of the complexities that arise from the shift in flood policy described above, there is a growing need to better integrate science and decision-making and develop an interface to combine different knowledge domains. Science can provide an important base of evidence to support decision-making processes (Pregernig, 2007), in particular in flood-related planning where decisions generally come with long-term commitments and a strong demand for anticipating future developments (Hallegate, 2009). However, incorporating new science in flood risk management practices and policy is challenging. Knowledge is fragmented among different scientific and technical communities, which are often not coordinated with officials at the different institutional levels where flood risk is dealt with. The variety of scientific disciplines studying the many aspects of hazards, exposure, vulnerability, resilience and coping capacity to prevent, prepare for or response to flood risks results in a large number of specialized scientific centres. Similarly, flood risk management is crosscutting across ministries and public agencies, not only involving emergency management, but also land use planning, finances, economy, environment, climate, etc. Legal competences in these policies fields are held by regional or even local governments, resulting in a complex science policy interface (De Groeve & Valles, 2015). Accordingly, one of the fundamental reasons for the lack of progress in our ability to mitigate and adapt to natural hazards is the continuing separation of research on natural processes and socio-economic processes without considering interaction between these systems (Fuchs & Keiler 2013), as well as between scientific research results and policy implementation (Medd & Marvin 2005).

Main research questions:

- *How does science inform flood risk management in Austria, Germany and Switzerland [AGS]?*
  - Who are the main actors at the science-policy interface in AGS flood risk management? What are their roles? [science, politics, stakeholders]
  - How do these actors mainly engage with each other? [contract research, advisory bodies, personal contacts, research programs, etc.]
  - How relevant is scientific expertise in Austrian, German, Swiss flood risk management? On which other sources of expertise do policy-makers rely?
  - How are research needs articulated and research priorities set? [by scientists, by policy-makers, by both; in which forms of institutionalization]
  - How are scientific findings transferred into the policy domain? [by whom, by means of which instruments, etc.]
  - How influential are scientists (and their expertise) compared to advocacy groups, ministry officials, and/or the public?
  - Have science-policy interactions in AGS flood risk management changed over time?

Methods:

- *document analysis (national and regional flood management strategies)*
- *Semi-structured interviews with policymakers and scientists (see Annex II)*

4. Flood risk governance and adaptation strategies

4.1 Flood risk governance

Current flood policies and flood risk governance frameworks should aim to develop strategies that address flood risk dynamics adequately. Risk governance is a process by which risk information is collected, analyzed and communicated, and management decisions are taken. On the one hand, risk governance strategies include operational flood management measures targeting the individual components of risk by reducing either the flood hazard or the vulnerability to flooding. On the other hand, they comprise governance processes, inter alia concerned with the horizontal coordination between different policy sectors, the vertical coordination between governmental levels, and stakeholder involvement. Deficits in risk governance practices can reduce the capacity of communities for resiliency and adaptation. Therefore two main dimensions have to be considered: (i) misfits in interplay between

different institutions involved in risk assessment, communication and management of flood risks (Young 2002), and (ii) misfits between institutions and stakeholders (Löfstedt 2005).
Governance of Flood Risk Management – The arrangement of actors, rules, resources and discourses that constitutes the policy regime for flood risk management. The governance arrangement can be thought of as the institutional constellations resulting from interplay between actors and actor coalitions involved in all policy domains relevant for flood risk management (water management, spatial planning and disaster management), their dominant discourses, formal and informal rules of the game, and the power and resource base of the actors involved. Accordingly the national policy regimes for FRM might vary to a substantial degree, thereby reflecting differences in framework conditions and politics.
Participation of relevant stakeholders: The involvement of people and stakeholders from the very beginning – as suggested in the EU Flood Directive – is often seen as a key element to deal with the complexities of flood risk, and to develop solutions that are mutually beneficial for all stakeholders. However, public participation in flood risk management is not an easy challenge and often falls short of the intended results. Some of the problems such as distrust in authorities, access to decision-making, difficulties in understanding, non-transparency, missing stakeholders and acceptance can be minimized with governance related approaches. Participation of various sectors and stakeholders is needed for finding a comprehensive solution to flood risks. Therefore, the flood policy context must include multi-disciplinary, multi-sector, multi-stakeholder participation. The inclusion of actors, stakeholders and the public throughout the complete governance process may gain more knowledge in the phase of assessment and later in the management process, as well as innovative solutions.
Provision of resources: flood risk management depends on the provision of certain resources (time, money, manpower, etc.) to support the governance process. However, these are limited resources, thus the effectivity of measures is important.

Main research questions:

- *Which sectors and stakeholders are identified as relevant for flood risk management? To what extent are they involved in flood risk management?*
- *How are flood risk management policies (both objectives and measures) coordinated horizontally across different sectors and vertically across levels of government?*
- *To what extent does the governance arrangement (i) consider the broadening of measures/strategies, (ii) support coordination between measures/strategies?*

Methods:

- *Literature and document analysis (national and regional flood management strategies)*
- *Semi-structured interviews with policymakers (see Annex II)*
- *(Exemplary analysis of selected flood management projects in the case study regions)*

4.2 Adaptation strategies of flood risk management

In this study, we define adaptation as the totality of measures, processes and strategies, which are implemented in flood policymaking to reduce the risk of flooding in an ever-changing and uncertain risk environment. According to this understanding, adaptation does not include private adaptation measures, such as voluntary flood insurance or voluntary flood-proofing. Building on the notion of flood risk management as “a continuous process of adaptive management” (Hall and Solomatine 2008) we distinguish two types of adaptation strategies, namely strategies of risk reduction and strategies of uncertainty management. Strategies of risk reduction employ a set of structural and non-structural measures aimed at hazard and/or vulnerability-reduction. Strategies of uncertainty management relate to the way in which policy makers handle knowledge uncertainties in deriving flood risk management policies and measures. In Flood-Adapt we are interested in showing similarities and differences in risk reduction strategies and uncertainty management strategies between flood policies in Austria, Germany and Switzerland.

4.2.1 Strategies of risk reduction

In recent years the emphasis in flood policy has shifted away from large-scale engineering measures (i.e. flood protection) towards the promotion of a broader range of risk reduction measures (i.e. flood risk management) (Penning-Rowsell et al., 2008; van Ree, 2011). As illustrated in Figure 4, risk reduction strategies today consist of a range of structural and non-structural measures, which can be attributed to the respective aims of flood hazard reduction and vulnerability reduction (Harries and Penning-Rowsell, 2011).

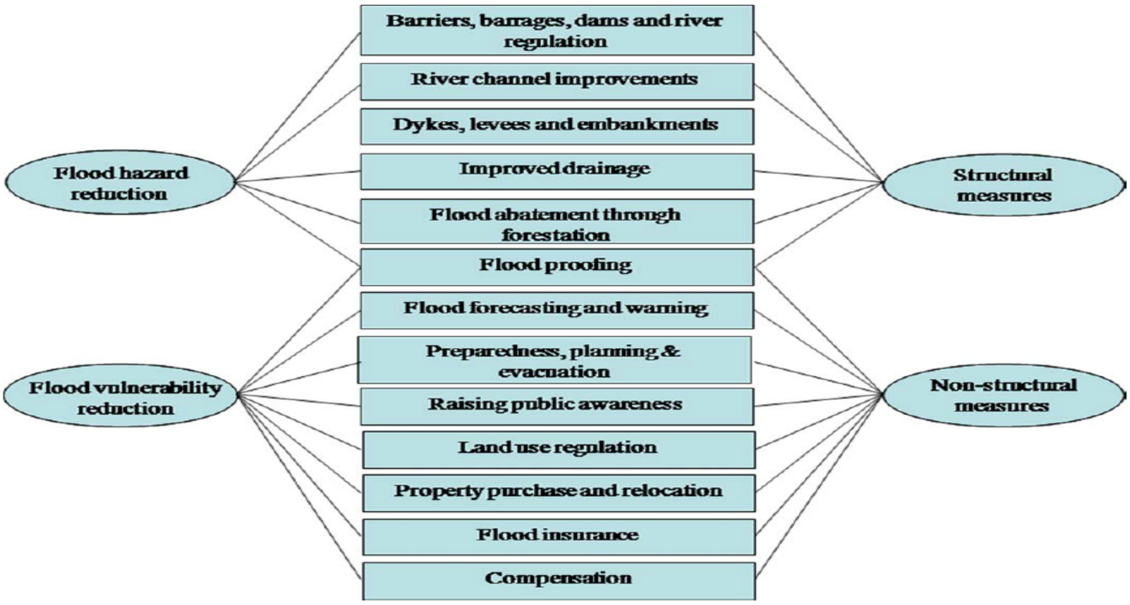


Figure 4: A categorisation of flood risk management measures

In the following table, those structural and non-structural measures which are predominately implemented by public policy actors are further integrated with regard to their main objectives, i.e. to reduce either the flood hazard or the vulnerability to flooding (Alfieri et al., 2016; Bubeck et al. 2013; Hegger et al. 2013):

Hazard-reduction strategies	Vulnerability-reduction strategies
Reduce and delay peak flows: e.g. controlled flooding of retention basins, natural water retention measures *Increase flood protection levels*: e.g. elevation of riverbanks through permanent or temporary barriers, i.e. “keeping water away from people”)	*Adapt land uses*: zoning regulations for the allocation of vulnerable land uses (“keeping people away from water”) *Mitigate flood damage*: dry flood-proofing (e.g. sandbags, door panels) and wet flood-proofing, e.g. strengthen walls against water pressure, use of waterproof materials *Relocate:* Relocate exposed people and assets at risk to areas with negligible risk

Table 1: Systematic overview of flood management strategies with regard to hazard and vulnerability reduction

Distinguishing flood risk reduction measures according to their principal objective of hazard or vulnerability reduction is helpful to identify the problem-orientation of particular measures. For instance, increasing the level of flood protection by adding a climate change allowance to the design magnitude of flood barriers (as in the case of Bavaria) is a hazard-reduction measure, which addresses the problem of expected climate change-induced increases in peak discharge. On the other hand, adapting land uses through zoning regulations or mitigating flood damage through flood-proofing are vulnerability-reduction measures, which address the issue of settlement growth near rivers and the rise in the concentration of values in these areas. [Note: vulnerability reduction measures can be employed as means to reduce the increase in damage potential in existing hazard areas but also as means of climate change adaption, such as when exposed people and assets are relocated from expanding flood hazard areas, see Figure 3 (Section 2).]
As illustrated in Figure 2 (Section 1.2) risk reduction strategies address a particular problem framing, but they are also the result of negotiation and coordination processes across different levels of government, policy sectors and interest groups on the basis of existing legal frameworks. In many cases scientific findings are transferred into the policy domain (see section 3), but the respective scientific recommendations and findings may not be reflected in the applied risk reduction strategies and measures.

Main research questions:

- *How do governments currently pursue flood risk management? What are the main approaches to implement flood risk management?*
    - *Which hazard and vulnerability reduction strategies (and corresponding structural and non-structural measures) are currently pursued in the three countries?*
    - *Which constituents of flood risk change (i.e. climate change and/or settlement development in river basins) do the strategies and measures address?*
    - *In how far do policy makers at different levels of government base their measures and strategies of risk reduction on scientific findings (i.e. evidence-based scientific knowledge) or practical (i.e. experience-based) knowledge?*
- *Which factors influence (foster or inhibit) the implementation of scientific recommendations (policy advice) regarding the respective risk reduction strategies and measures?*

Methods:

- *Data base analysis (Hochwasser-Fachdatenbank)*
- *Document analysis (national and regional flood management strategies)*
- *Semi-structured interviews with national and regional policymakers (see Annex 2)*

4.2.2 Strategies of uncertainty management

Due to the long-term character of many risk reduction strategies and measures outlined above, flood policymaking faces the need to anticipate (or consider) expected changes in flood risk. Potential climate induced-changes in flood hazard and the likely impacts of land use change on vulnerability are however subject to considerable uncertainty and regional variation (see section 2). This raises the question how policymaking should proceed in the face of uncertainty. The scholarly literature generally distinguishes two strategies (Kuklicke and Demeritt 2016): on the one hand, risk-based approaches aim at closing down the vast space of future possibilities by attributing probabilities and consequences to them. One the other hand, adaptive management approaches seek to keep the management process open to the uncertainties inherent in future developments by highlighting the conditionality and contestedness of current knowledge about the future (Holling, 1978).

Risk-based approaches

A risk-based approach is one that explicitly considers the probability and consequences of harmful events (Hall et al. 2012:126). Rather than trying to eliminate all potential harms, risk-based approaches aim for an optimal balance between socially acceptable levels of risk and the costs of further risk reduction. Risk-based approaches to climate change seek to identify optimal policy solutions based on ex ante assessment to distinguish reasonably acceptable from unacceptable outcomes, given the various costs and benefits involved in reducing their probability and consequences. Uncertainties are acknowledged in this approach and managed through different forms of probabilistic risk assessment (e.g. Monte Carlo simulation, ensemble prediction) to quantify them within confidence intervals (Kuklicke and Demeritt 2016:57-58).
[Note: The example of a climate change allowance for estimates of peak discharges and design levels of flood protection infrastructure qualifies as a risk-based approach. It allows to transform “the unknown possibility of changes in the magnitude of future flooding due to climate change into a calculable number that allows management decisions to be made” (Kuklicke and Demeritt 2016:61-62). This measure however is also described as a “single precautionary allowance” for climate change (Kuklicke and Demeritt 2016:61) and thus qualifies as an example for a policy decision based on the precautionary principle.]

Adaptive management approaches

Adaptive management approaches seek to keep the management process open to the uncertainties inherent in future developments. Adaptive management approaches endorse flexibility and experimentation to enable policymakers to change course in response to new information (Holling, 1978, Pahl-Wostl, 2006 and Allen et al., 2011) and avoid decisions that lock-in long term policy commitments that would be costly to fix if ex ante assessments prove wrong (Wilby and Dessai, 2010 and Hall et al., 2012).
From a normative point of view, the following approaches of adaptive management can be distinguished (Hallegate 2009):

- **No-regret strategies**: yield benefits even in the absence of climate change (examples include early warning systems which are costly but can substantially reduce the flooding vulnerabilities in multiple future hazard scenarios; spatial adaptation or damage mitigation measures (such as flood-proofing of buildings) however do not qualify as no-regret strategies because they may produce high costs if the increase in hazard is lower than expected
- **Reversible strategies**: aim to keep as low as possible the cost of being wrong about future climate change; e.g. easy-to-retrofit defences or delaying the development of flood-prone areas or a step-by-step development of flood-prone areas)
- **Safety margin strategies**: aim to reduce vulnerability at low costs by increasing e.g. the height of dikes (however: danger of “levee effect”)¸ safety margins are only relevant for adaptation measures that are not reversible or flexible
- **Soft strategies:** aim to enhance preparedness through institutional and financial tools (e.g. insurance or evacuation schemes); land use and building restrictions do not qualify as soft strategies due to their hard influence on investment options)

- **Strategies that reduce decision-making horizons:** aim at reducing uncertainty through shorter investment lifetimes (e.g. build cheaper houses with shorter lifetimes in potential flood hazard areas)

Due to the long-term character of flood management decisions on the one hand and the uncertainty of future developments on the other, strategies of risk reduction in many cases also figure as strategies of uncertainty management. For instance, adding a climate change allowance to the design magnitude for flood protection infrastructure pursues the aim of hazard reduction but at the same time qualifies as a risk-based/precautionary approach (or adaptive management approach?) of handling knowledge uncertainties. Similarly a step-by-step approach of floodplain development aims at minimizing the increase in flood damage and vulnerability, but also is an example for an adaptive management approach.

The following criteria will be used to assign risk reduction strategies to the different strategies of uncertainty management:

- time-scale of measures (e.g. flood protection infrastructure, spatial planning)
- potential for creating a lock-in situation
- (...)

Main research questions:

- *Which strategies of uncertainty management are identified in adaptation literature? How can/should flood policy making proceed in the face of uncertainty?*
- *How do policy-makers in AUT, GER and CH currently handle scientific uncertainties? Do they acknowledge or ignore uncertainties?*
- *Under what circumstances are they prepared to adhere to risk-based approaches or adaptive management approaches (including precautionary approaches of adapting current policies to possible future changes despite of uncertainties)? How do these approaches look like?*
- *To which extent do the countries' approaches constitute risk-based or adaptive management strategies?*

Method

- *Literature review (peer reviewed publications, studies and assessments)*
- *Document analysis (national and regional flood management strategies)*
- *Semi-structured interviews with national and regional policymakers and scientists (see Annex 2)*

5. Understanding different responses: comparative conclusions

5.1 Case study selection

Based on the analytical framework outlined above we will analyse flood risk management policies in Austria, Germany and Switzerland. "To make sure that the German and the Swiss cases address the

issues relevant from an Austrian perspective in a comparable way, they will be conducted after the Austrian case, based on a revised analytical framework that will take the findings of the Austrian case study into consideration. (...) To consider the fact that flood risk management policies are a multi-level endeavour that spans across different levels of government (in particular in federal states), we will look not only at national policies but also at two selected provinces (Länder/Kantone). The case study regions are chosen mainly based on their topography and their vulnerability with regard to flooding. They are characterised by Alpine Spaces and/or by Alpine foothills and hilly countryside. The case study regions are most likely Salzburg and Lower Austria in Austria (see the support letters from the two provinces in Annex 5.2), Bavaria and Baden Württemberg in Germany as well as Bern and Valais in Switzerland (to be confirmed once the desk research for the analytical framework is completed)" (FloodAdapt Proposal 2014:7-8).
The selection of case study regions is based on the following criteria:

- high flood risk dynamics: expected climate change impacts on the one hand, scenarios of settlement development and population change on the other hand (see Section 6, Annex)[1]
- topography: combination of alpine areas, alpine foothills and lowland
- data availability: e.g. flood risk management strategies, climate change adaptation strategies, planning documents, data on flood protection expenditures)

5.2 Cross-case comparison: constraints and enabling factors for adaptation

Flood-Adapt will unravel the political puzzle why three neighbouring countries with similar flooding vulnerabilities pursue different courses in mainstreaming adaptation into flood protection at different levels of government. By doing so, it will highlight the factors that determine adaptation mainstreaming. The cross-case comparison will describe and analyse what similarities and differences we find between the three countries regarding both uncertainty management and adaptation strategies (including the role of science and expertise therein) and how can they be explained?

Main research question:

- *How different are flood risk management policies (adaptation strategies and risk reduction measures) in the three countries?*
- *What factors explain different approaches towards adaptive flood risk management (how scientist and policy makers frame the problem structure, quality of science/policy interaction, flooding events, institutional framework conditions, available resources, differences in risk governance, political learning)?*

Studies on adaptation and integrated flood risk management indicate that a number of factors may influence the extent to which adaptation policies and practices are developed.
First of all, differences in **legal and administrative structure** may affect the way in which adaptation is developed in different countries. This refers in particular to the role of government in different political

[1] Oberösterreich ist das einzige Bundesland, in dem in Teilgebieten (Mühlviertel) eine klimawandelbedingte Zunahme der Hochwassergefährdung zu erwarten ist. Die Region grenzt im Süden an den OÖ Zentralraum, der eine hohe Bevölkerungs- und Siedlungsdynamik aufweist. Alleine unter diesen Gesichtspunkten wäre OÖ eine interessante Fallstudie; darüber hinaus verfügt OÖ noch über eine aktuelle KW-Anpassungsstrategie (http://www.land-oberoesterreich.gv.at/files/publikationen/us_klimawandelanpass.pdf) und im Bereich der Raumplanungsgesetzgebung wurden kürzlich relevante Änderungen in Richtung Vulnerabilitätsreduktion verabschiedet.

structures (Keskitalo, 2013; Harries and Penning-Rowsell, 2011). The choice of flood risk management strategy is typically not restricted by legal and administrative constraints, even the 2007 European Floods Directive stops short of insisting on whether and how adaptation to flood risk should occur (Harries and Penning-Rowsell, 2011). In line with the new paradigm of flood risk management central governments seek to broaden their portfolio of adaptation measures. In federal countries such as Austria, Germany and Switzerland, however, flood risk management is typically organized in a more decentralized way with competences for decision-making and implementation also held by the provincial and local level. This plural decision-making process has its advantages because it guarantees that local knowledge about flood risks is incorporated, but is also leaves a high level of discretion to regional and local decision-makers about whether and how to respond to particular flood risk situations. There is also a risk of inadequate institutional arrangements for horizontal and vertical cooperation between decision-makers (Clar et al, 2013). The impact of front-line resistance to policy shifts, according to Harries and Penning-Rowsell (2011), is particularly acute in situations where a separation of the functions of policy making and policy implementation has loosened the control of central government policy-makers over the delivery of policy.

Another institutional barrier to policy change that is often cited in the literature are path dependencies and policy feedbacks – the legacies of previous policies and the resulting institutional inertia. (Harries and Penning-Rowsell, 2011; Keskitalo, 2013; Clar and Steurer, 2016). Usually, the literature on policy feedback refers to the legacy of systems and procedures created by previous policies. One example in the arena of flood risk management is the use of benefit cost analysis and the need to attain high benefit-cost ratios for priority projects, which creates a procedural preference for structural measures. Policy feedbacks can also leave cultural legacies, for example, by impacting on the social identity and administrative culture of organizations ("engineering school").

The resistance resulting from policy feedback can be overcome by exogenous shocks or critical events: events that shake the legitimacy of the assumptive worlds within the architecture of social identities and thereby facilitate change. As a result, exogenous shocks create windows of opportunity in which policy change is more possible (Albright, 2011; Birkland 1997, 2006).

Effective adaptation policies usually require adequate financial resources (Smit and Pilifosova, 2001). As Aaheim and Aasen (2008) point out, even if there is consensus regarding certain adaptation actions, limited budgets often prohibit their implementation. Moser and Ekstrom (2010) emphasize that piecemeal approaches are not enough: "more resources just for science but not for implementation or for monitoring does not result in a greater likelihood of adaptation actions being implemented on the ground".

A considerable lack of evidence or certainty regarding global climate scenarios, regional climate change impacts, or the costs and benefits of policy options may also constrain policymakers from addressing climate change adaptation adequately (Clar et al. 2013). The uncertainties regarding climate change and adaptation that concern policymakers are often due to scientific or methodological problems in predicting future developments and impacts.

The final barrier we identified in the adaptation literature addresses problems related to learning from scientific knowledge or practical experiences (Clar and Steurer, 2013; McFadden et al, 2009; Keskitalo, 2013). Policy learning can be hampered by the inadequate brokerage of scientific knowledge. Even if scientific evidence is (relatively) certain, inadequate interfaces between science and policymaking can prevent it from being acted upon in the political sphere. Problems frequently referred to in this context are different rationalities and languages in science and policymaking (Hinkel, 2011), and a lack of adequate knowledge-brokerage institutions that can help to bridge these and other differences. In addition, policy learning can be hindered by a lack of networking and exchange among policymakers.

6. Annex

6.1 Annex I: Criteria for case selection

6.1.1 Expected climate induced changes in flood hazard

Ergebnisse der Studie „Anpassungsstrategien an den Klimawandel für Österreichs Wasserwirtschaft" (BMLFUW 2011)

- „Prognosen über Hochwasseränderungen sind nach dem derzeitigen Kenntnisstand nicht möglich, da die zukünftige Entwicklung der Extremwerte des Klimas nicht ausreichend zuverlässig berechnet werden kann (harte Aussage).
- Szenarienrechnungen aus der Literatur über zukünftige Änderungen der Hochwässer an Österreichischen Flüssen unterscheiden sich erheblich (harte Aussage).
- Da Klimamodelle keine Aussagen über zukünftige Extremniederschläge machen können, sind die Unsicherheiten groß, besonders in kleinen Gebieten.
- Hier durchgeführte Wenn-Dann Szenarien, die die unterschiedlichen Mechanismen der Hochwasserentstehung und ihre Saisonalität abbilden (Änderung der Winter/Sommerniederschläge, Erhöhung der Schneefallgrenze, Erhöhung des Anteiles konvektiver Niederschläge, frühere Schneeschmelze und Erhöhung der Verdunstung) zeigen Änderungen der hundertjährlichen Hochwässer in einem Bereich von –4 bis +10% und eine Verschiebung des jahreszeitlichen Auftretens der Hochwasser (frühere Frühjahrshochwässer, mehr Winterhochwässer) für einen Zeithorizont 2021-2050 im Vergleich zu 1997-2007 (weiche Aussage)." (S. 3-1f.)

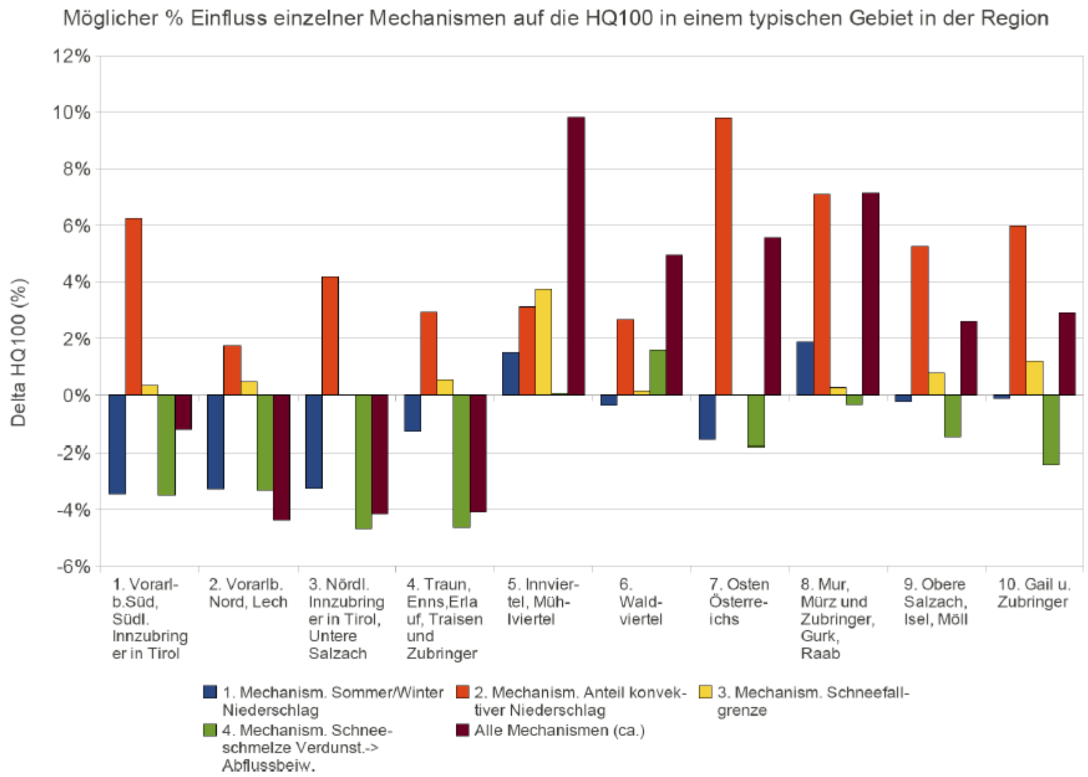


Abbildung 3-52: Sensitivität der HQ_{100} bei bestimmten Annahmen der Änderungen im Niederschlag und der Abflussbildung (Wenn-Dann Szenarien 2021-2050 im Vergleich zu 1976-2007).

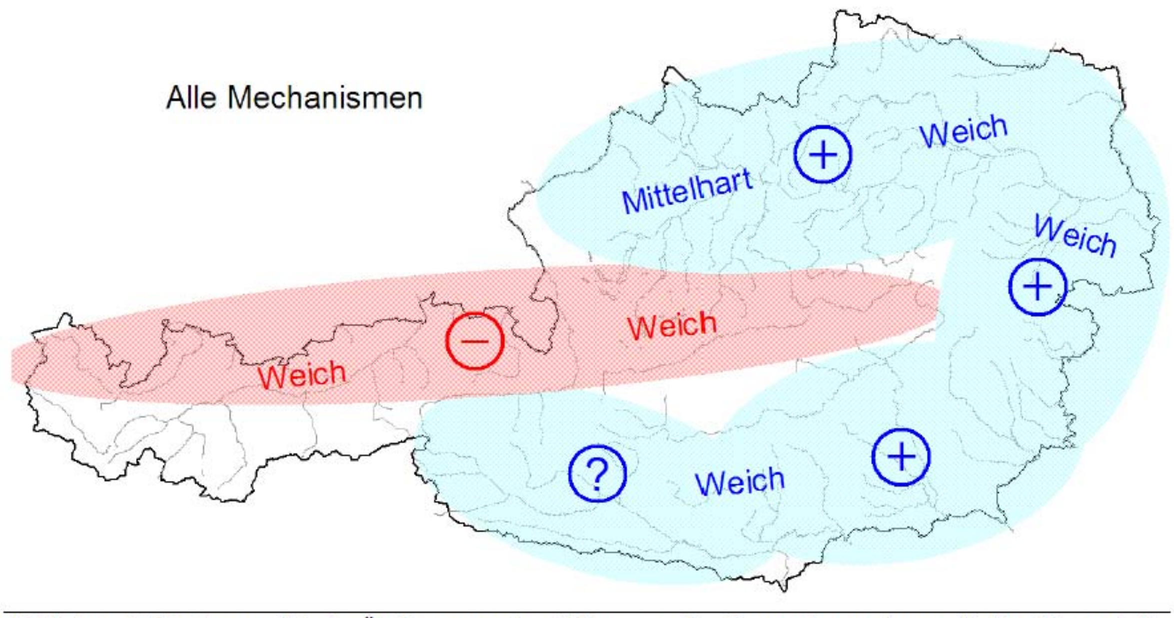


Abbildung 3-54: Generalisierte Änderungen des HQ_{100} aus den Szenarienanalysen (Delta-Change) für alle Mechanismen gemeinsam. 2021-2050 im Vergleich zu 1976-2006.

<u>Ergebnisse der Studie RiskAdapt (Nordbeck et al. 2015)</u>
Für die Ermittlung der zukünftigen Gefährdung (Abbildung 1, links) wurde die relative Änderung der überfluteten Flächen zwischen HQ200 und HQCC herangezogen (auf Basis eines Klimawandelzuschlags i.d.H. von +10%, s. BMLFUW 2011). Dabei wurde folgende Klassifikation für die Einteilung der zukünftigen Gefährdung vorgenommen:

Zukünftige Gefährdung - Relative Änderung der Überflutungsflächen bei HQ_{cc}, bezogen auf HQ_{200}				
marginal	niedrig	mäßig	hoch	sehr hoch
[0-5%]	[5-10%]	[10-25%]	[25-50%]	[>50%]

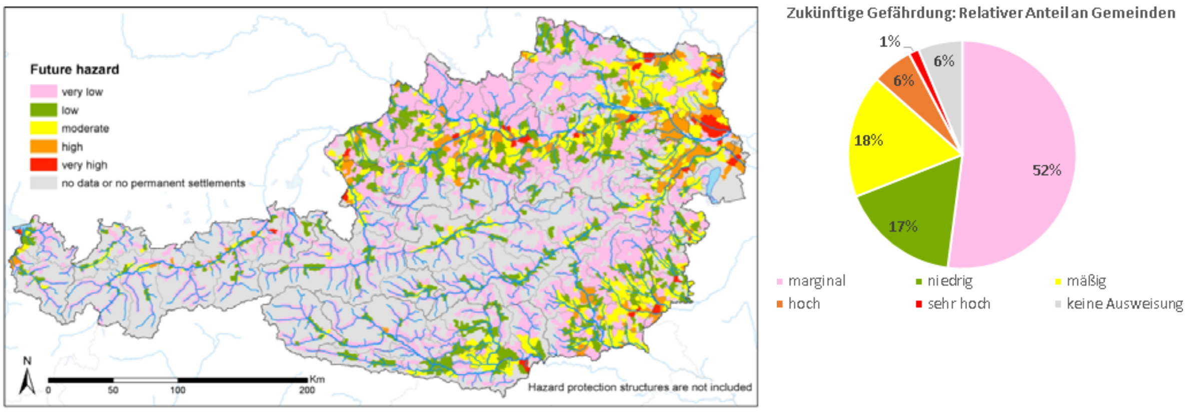


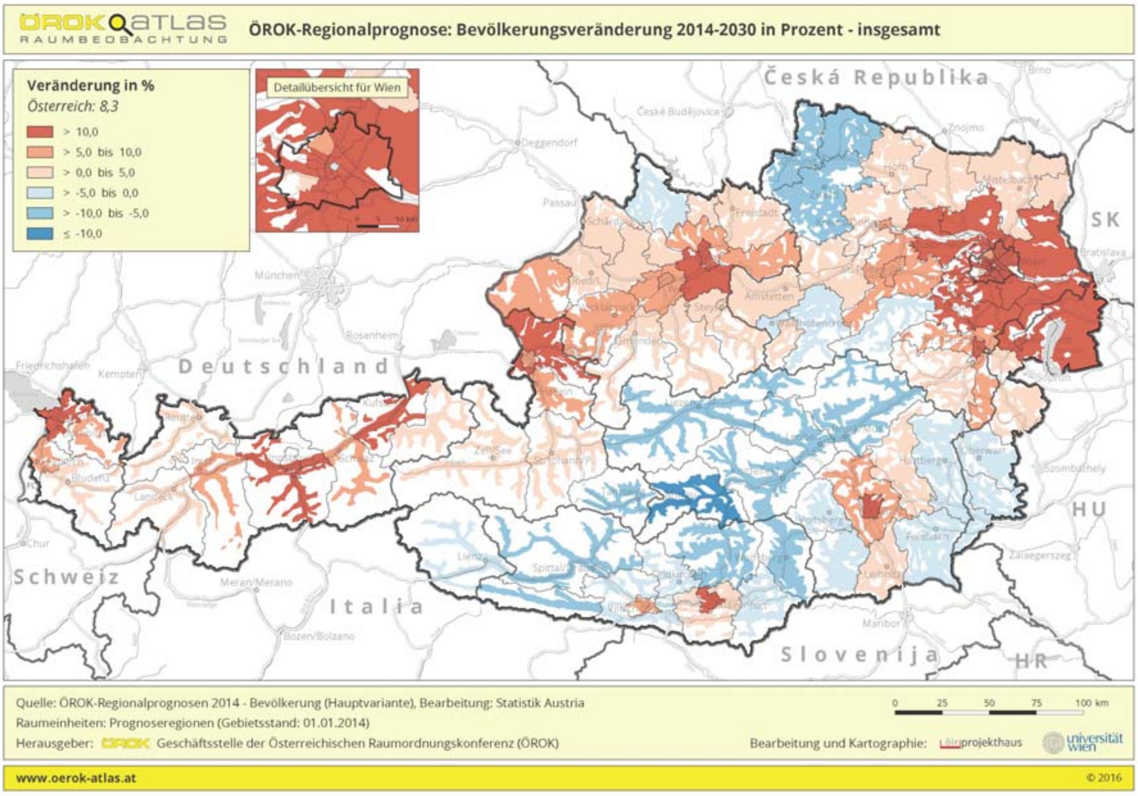
Abbildung 1: Darstellung der zukünftigen Hochwassergefährdung und relative Anteile der Gemeinden an den Gefährdungsklassen

Generell nimmt, wie zu erwarten ist, die Gefährdung in Gemeinden mit relativ flacher Topographie zu. Die zukünftige Gefährdung zeigt, dass bei fast 70 % der Gemeinden im Zukunftsszenario eine marginale oder niedrige Gefährdung auftritt (Abbildung 1, rechts). Bei diesen Gemeinden kommt es trotz Erhöhung des Abflusses zu keiner nennenswerten Vergrößerung der Überflutungsflächen. Diese Gemeinden finden sich in weiten Teilen Österreichs und liegen sowohl in den alpinen Bereichen, aber auch in flacheren Gebieten, wie dem Mühlviertel oder Teilen der Steiermark. Rund 25 % der Gemeinden weisen eine mäßige bis sehr hohe zukünftige Gefährdung auf. Diese Gemeinden liegen hauptsächlich in Bereichen entlang der Donau, dem Wein- und Waldviertel, südlich von Wien und Bereichen in der Süd-Ost Steiermark.

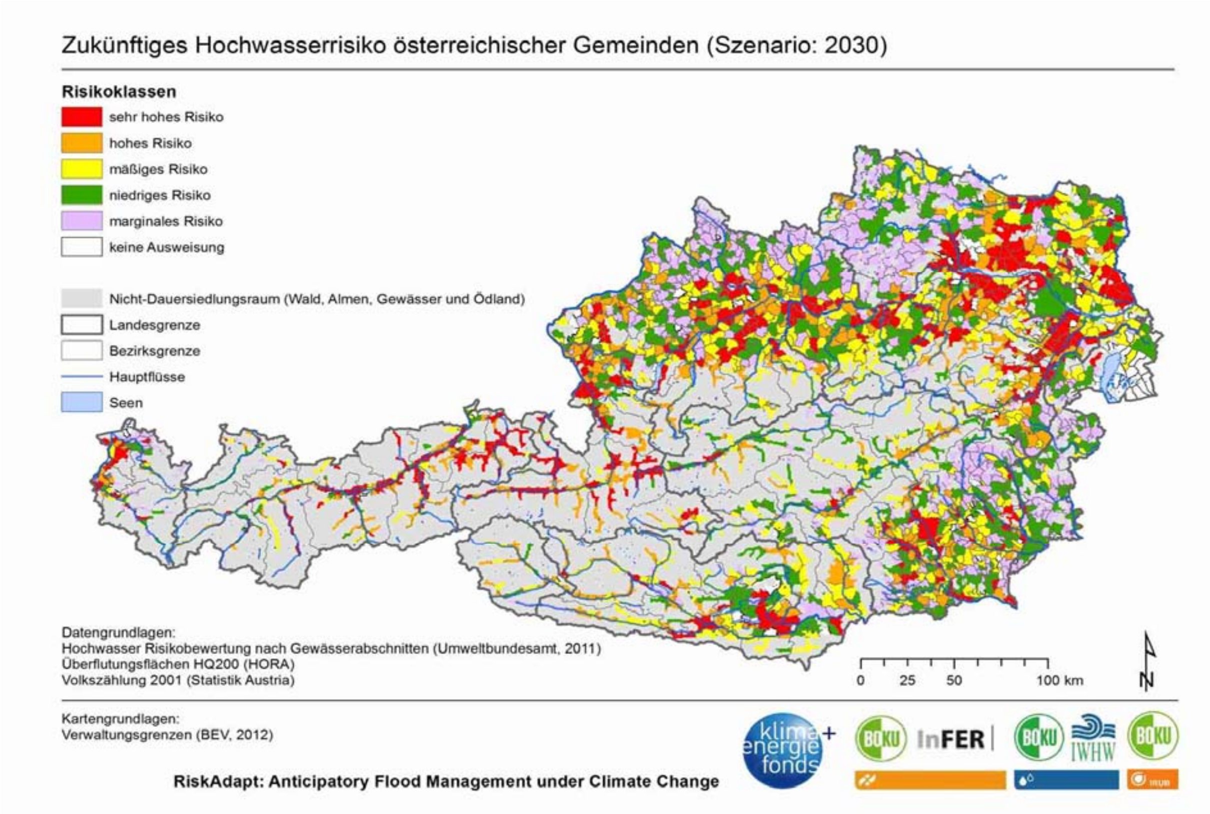
6.1.2 Expected land use induced changes in flood risk

<u>ÖROK-Atlas: population change 2014-2030</u>

Population change is a key indicator of expected changes in vulnerability. The Austrian Conference on Spatial Planning (ÖROK) provides regional scenarios of population change (on the level of political districts) until the year 2030.



<u>Ergebnisse der Studie RiskAdapt (Nordbeck et al. 2030)</u>
Findings from the ACRP-funded project RiskAdapt show strong local and regional differences with regard to expected future changes in flood risk. The assessment considers potential spatial and temporal developments until the year 2030 for both aspects of risk - hazard and vulnerability. Climate change induced increases in flood hazard were assessed based a uniform consideration of a climate change allowance (+10%) based on the findings of BMLFUW 2011; the assessment of expected changes in vulnerability is based on exposure indicators (share of total population in HQ200 hazard area and scenarios of population change 2012-2030).


Zukünftiges Hochwasserrisiko österreichischer Gemeinden (Szenario: 2030)
Risikoklassen
sehr hohes Risiko
hohes Risiko
mäßiges Risiko
niedriges Risiko
marginales Risiko
keine Ausweisung
Nicht-Dauersiedlungsraum (Wald, Almen, Gewässer und Ödland)
Landesgrenze
Bezirksgrenze
Hauptflüsse
Seen
Datengrundlagen:
Hochwasser Risikobewertung nach Gewässerabschnitten (Umweltbundesamt, 2011)
Überflutungsflächen HQ200 (HORA)
Volkszählung 2001 (Statistik Austria)
0 25 50 100 km
N
Kartengrundlagen:
Verwaltungsgrenzen (BEV, 2012)
RiskAdapt: Anticipatory Flood Management under Climate Change
klima energie fonds
BOKU
InFER
IWHW