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The status of climate risk management in Austria. Assessing the governance landscape and proposing ways forward for comprehensively managing flood and drought risk

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ABSTRACT

Climate and weather-related damage have been increasing globally in recent decades. Due to climate change and socio-economic developments, a further increase in climate-related risks is expected. Numerous countries have a long and successful history in disaster risk management (DRM) to avoid, minimize and manage damage caused by extreme weather events. In addition, climate change adaptation (CCA) focuses on managing the risks resulting from climate change today and in the future. To improve the effectiveness and efficiency of managing climate-related risks, these two independent approaches need to be linked closer in a more holistic approach – a concept that has been termed climate risk management (CRM). In order to build stronger ties in practice, it is crucial to first understand current governance structures in specific countries or regions. This paper focuses on Austria, a country with experience in both DRM and CCA. In this paper, we present a comprehensive picture of the stakeholder landscape and governance structures in the context of managing climate-related risks. We focus on flooding and agricultural drought, two key risks in Austria. Building on a literature review and a two-stage stakeholder process, consisting of stakeholder interviews and stakeholder workshops, relevant institutions and actors were identified and assigned to a 4-phase CRM cycle. Moreover, specific activities of the identified actors and interactions between them were determined. Based on these insights, we conclude that a comprehensive CRM, which aligns DRM and CCA practice, does not yet exist in Austria. We propose to establish the missing CRM decision-making structures by e.g. instituting a legally-anchored national climate risk council, which can act as an interface between CRM practice and political decision-making.

1. Introduction and background

Damage and losses caused by weather and climate-related extremes, such as floods, droughts, storms and heatwaves have increased over the past decades in many regions around the globe, and will likely further increase with the progression of climate change and socioeconomic development (IPCC, 2012, 2014; UNISDR, 2015; Schipper et al., 2016; Mall et al., 2019).

In the case of Europe, for example, weather-related disasters could affect around two-thirds of the European population annually by

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the end of this century. This could result in a 50-fold increase in fatalities compared to today, if no measures are taken (Forzieri et al., 2017). Without adequate adaptation, damage to critical infrastructure in Europe due to climate extremes may increase on average six-fold by mid-century, with the highest losses in transport, energy and industry which face a 15-fold increase (Forzieri et al., 2018).

Austria faces numerous hazards, most notably riverine flooding and agricultural drought. The country suffered substantial damage of several billion Euro due to riverine flooding in 2002, 2005, and 2013, leading to stress on private and public financial reserves. Insured losses from agricultural drought in the years 2013–2019 average € 123 million per year. This figure is higher than combined agricultural losses from hail, frost, storm and floods that average € 88 million per year (Austrian Hail Insurance, 2019).

As one of the first bodies to conduct a comprehensive national assessment of climate change, in 2014 the Austrian Panel on Climate Change (APCC) showed that warming, in terms of average temperature increase relative to pre-industrial levels in Austria has been more severe than the global average, that climate-related risks are certain to increase (both due to climate change as well as socio-economic development) and that, overall, there is a need to upgrade adaptation efforts (APCC, 2014). A country-wide assessment of the costs of climate change was published in 2015, detailing the significant financial implications of unmitigated climate change for public and private actors, amounting to about a billion Euro already today (Steininger et al., 2015).

With climate change being widely acknowledged to be a key driver for increasing disaster risk, science, policy and practice stress the need for better linking of Disaster Risk Reduction (DRR) and climate change adaptation (CCA). Comprehensive management of climate-related risks is essential for effectively confronting the challenges at the intersection of climate change adaptation and natural disaster risk management (Fig. 1). The UNDRR notes that the multidimensional nature of interrelating climate and disaster risks requires "systemic approaches, that seek to understand the nature of interacting systems and adopt integrated risk governance" (UNDRR, 2019). Such an integrated approach would lead to making more efficient and effective use of scarce public resources, by pooling resources and expertise, and avoiding overlaps (Islam et al., 2020; Howes et al., 2015). This systemic and integrative approach has become known as comprehensive climate risk management (CRM) (IPCC, 2012) and has also been conceptually suggested for Austria (Schinko et al., 2017).

As DRR and CCA often fall into the remit of the public sector, which is widely considered to be responsible for the safety, security and well-being of the general public, for the effective use of public resources, and for stepping in as the lender of last resort, an integrative approach to managing climate risks becomes increasingly important. Moreover, the private sector, in particular the investment process of asset owners and managers, is becoming aware of the impact of climate-related risks to their balance sheets (EY, 2017).

Despite the growing recognition for the need to synergistically address DRR and CCA in an integrative manner, little research exists on how to operationalize CRM in practice, what governance challenges are associated with it and what is needed to overcome these challenges. A recent systemic literature review identified the following key challenges for integration: lack of capacity among actors and institutions, policy gaps, mismatches, governance failure, lack of coordination, fund-shortages, and obstructive influence from influential decision-makers (Islam et al., 2020). In the following we summarize more specific evidence from international case studies, which also forms the basis for our Austrian case study.

1.1. CRM governance challenges identified in other countries

Howes et al. (2015) discuss challenges in managing three extreme climate-related events in Australia between 2009 and 2011, and conclude that a strategy to improve inter-agency communication and collaboration would be a key factor in this type of policy/planning integration supporting networked governance. Five reforms were proposed: developing a shared policy vision; adopting multi-level planning; integrating legislation; networking organizations; and establishing cooperative funding. (Howes et al., 2015).

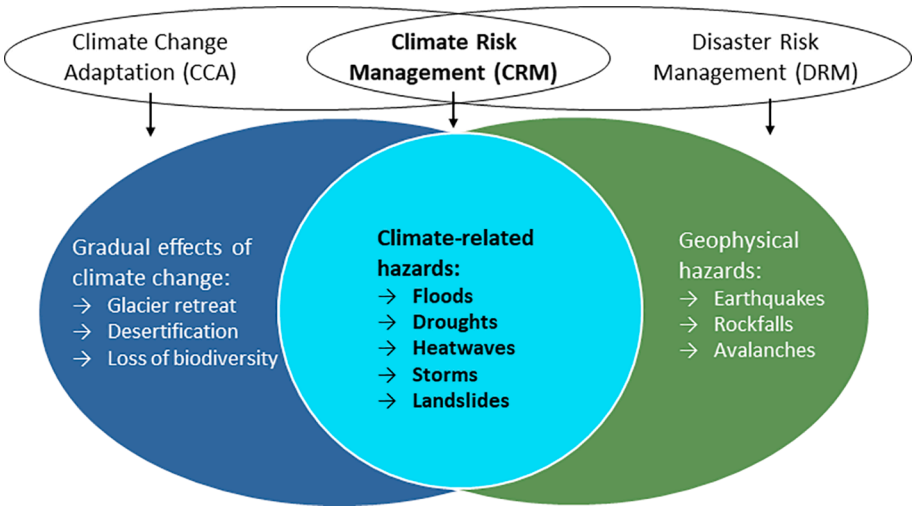

Fig. 1. Joint challenge between Climate change adaptation and natural disaster risk management – Climate Risk Management (CRM).

Further research on local governance of CCA and DRR integration in Australia revealed that there are emerging opportunities, such as the promotion of participation mechanisms in planning, the creation of partnerships with local stakeholders and the use of coordination organizations and platforms that can strengthen governance mechanisms at the local level (Forino, et al., 2018).

A case study focusing on Nicaragua showed that fragmentation of knowledge, information and the flow of coordination between different governance levels (e.g. local to national) causes little integration between DRR and CCA at local-level risk management planning and practice, and hence poses challenges to the effective management of extreme event risks (Rivera et al., 2015). In the case of Zambia, the need for improved horizontal and vertical governance as well as the reduction of potential inefficiencies in governance and policy implementation were identified as a challenge in terms of the policy integration of DRR and CCA in Zambia. (Pilli-Sihvola and Väätäinen-Chimpuku, 2016)

Findings from the ESPREssO project (Enhancing Synergies for disaster PRevention in the EurOpean Union) conclude for the European Union that: "institutional barriers are identified as a key challenge that hinders the process of successful integration of CCA into DRR. In most of the countries climate change-related policies and decisions are made by the ministries and organisations related to the environment, whereas disaster management and reduction decisions are made by ministries related to civil protection and infrastructure development. This institutional structure disturbs the communication process, which generates an information barrier among the institutions. Integration of CCA and DRR is not a legal mandate in most EU countries. Many have legal provisions for civil protection as a mandate of DRR. Therefore, countries have short-term plans for DRR or plans for disaster response and recovery, rather than a long-term strategic plan to reduce disaster risk by integrating CCA. […] Given the comprehensive nature of the challenge of DRR and CCA, obviously other institutional actors play a role in the complex governance system" (Amaratunga et al., 2017).

Focusing explicitly on the UK, the Espresso Project identified governance challenges of CCA and DRR such as institutional barriers, communication challenges and differing understanding of risk concepts in addition to challenges in funding issues, based on existing legal and policy instruments (Dias et al., 2018).

Governance strategies suggested for flood risk management are also relevant for the governance of climate change adaptation. Key strategies that enhance flood resilience and secure the necessary capacities are (i) the diversification of flood risk management approaches; (ii) the alignment of flood risk management approaches to overcome fragmentation; (iii) the involvement, cooperation, and alignment of both public and private actors in flood risk management; (iv) the presence of adequate formal rules that balance legal certainty and flexibility; (v) the assurance of sufficient financial and other types of resources; (vi) the adoption of normative principles that adequately deal with distributional effects. (Driessen et al., 2018)

1.2. Research question and approach

Based on these insights from international case studies and in response to the need for further research on CRM governance, in this paper we focus on the case of Austria. Austria is heavily exposed to floods and an increasing frequency of droughts, often resulting in severe social and economic consequences (Steininger et al., 2015). Austria has longstanding expertise and experience in DRM and is at the forefront of CCA policy and practice (the OECD's Environmental Progress Report 2013 states that Austria's National Adaptation Strategy (NAS) is one of the most comprehensive one). Nevertheless, previous research has identified a strong need for better linking these two domains to manage climate-related risks more effectively and efficiently (Schinko et al., 2017).

Against this background we set out to answer the following research questions:

- What are the current governance structures at the intersection of DRM and CCA in Austria?
- How closely aligned are these areas in the Austrian decision and policy making practice?
- How can the activities be aligned more closely?
- What are universal lessons for CRM that can be learned from the Austrian case study?

We apply a qualitative approach, building on a comprehensive assessment of peer-reviewed as well as grey literature in combination with a two-stage stakeholder process, consisting of stakeholder interviews and two stakeholder workshops, in order to achieve comprehensive mapping of actors and institutions within Austria's existing DRM and CCA governance structures that can potentially contribute to comprehensive CRM, and to identify elements implementation challenges in the context of CRM in Austria.

The remainder of the paper is organized as follows: Section 2 provides a detailed description of the methods applied. Section 3 presents the results of the literature review and the stakeholder engagement process in light of the research questions above. Section 4 discusses our results in the context of the existing literature, both from an Austrian as well as from a universal perspective.

2. Methodological approach

The methodological core of the paper is based on a stakeholder analysis (Freeman 1984), typically used to gather information about actors and draw conclusions about their behaviour, interests and decision-making processes (Reed et al., 2009; Brugha and Varvasovsky, 2000). In this paper, the term stakeholder is understood as "any group of people organized, who share a common interest or stake in a particular issue or system" (Grimble and Wellard 1997, p. 3-4). Consequently, in the CRM case, stakeholders refer to those institutions that may or might play a role in the establishment and implementation of CRM (as conceptually suggested for Austria in Schinko et al., 2017), focusing on flood and agricultural drought risk in Austria, based on current active, interested or affected stakeholders in DRR, DRM and CCA. While we have mainly focused on public sector stakeholders in this research, we encourage the additional involvement of affected citizens as well as the private sector in future research.

The stakeholder analysis was applied to achieve two objectives: (1) to identify key actors at different levels (i.e. CRM stakeholder mapping), and (2) to analyse existing decision-making structures in the area of CRM (i.e. CRM governance), based on already existing and established actors and structures in DRM DRR and CCA. The following questions were used to guide the analysis:

- CRM stakeholder mapping: Which stakeholders are active, interested in or affected by CRM, and what are their responsibilities and activities?
- CRM governance: Which decision-making structures and related issues (e.g. decision-making bases, collaborations, and challenges) are already established in CRM?

We adopted a systematic approach to stakeholder analysis, following Reed et al. (2009). Fig. 2 gives a schematic overview of the approach applied in this paper. In the first phase, context, focus and system boundaries were determined (steps 1 and 2). In the second phase, we focused on the identification of relevant stakeholders, their categorization and the analysis of stakeholder relationships (steps 3, 4 and 5). In this paper, a combination of stakeholder interviews and workshops was used for the second phase. Taking an iterative approach, insights from the second phase were played back into the first phase, if necessary. In the third phase, conclusions and specific recommendations were derived.

2.1. Stakeholder interviews and workshops

After a screening of the literature on Austria's risk governance landscape, a tentative list of national, regional and local-level stakeholders was compiled. In a next step, personal (face-to-face) interviews were conducted with 14 selected stakeholders between August to October 2017, to identify responsibilities and activities, and to generate detailed insights into the governance structure, challenges and actor relationships. Table 2 provides an overview of the topics and questions addressed in the interview guidelines (see Appendix). The interviews were transcribed and returned to the stakeholders for approval and corrections.

In a second step, the results of the interviews were validated, supplemented and consolidated in two stakeholder workshops. The first workshop took place in March 2018, the second in April 2019. The participants of the first workshop were divided into two groups, one focusing on flood, the other one on drought risks. Both groups verified and extended the stakeholder maps that were prepared prior the workshop based on the preceding literature screening and stakeholder interviews. In addition, workshop participants detailed the relationships between stakeholders and evaluated decision-making structures. The initial stakeholder pool was continuously expanded in an iterative process between the two workshops.

The identified CRM actors were plotted on two stakeholder maps, one for each climate-related risk (see Results Section 3.1 on Stakeholder Mapping). Following a classic stakeholder mapping approach, we described relevant key actors with a focus on their objectives, options for action and interests within a policy area (Meyer et al. 2017).

2.2. Activity mapping along the CRM cycle

In the next step, actors' activities were summarized in the form of two stakeholder activity matrices, detailing CRM relevant activities for each stakeholder with respect to flood and drought risks (see Chapter 3.1 on Stakeholder Mapping). Activities were categorized based on the four-stages of the CRM framework (adapted from Schinko et al., 2017, who first developed this framework for the Austrian context). This CRM framework conceptually integrates CCA and DRM, particularly by aligning the differences in the time perspective of CCA and DRM. The integration of the well-established DRM cycle (prevention, preparedness, response, recovery) with

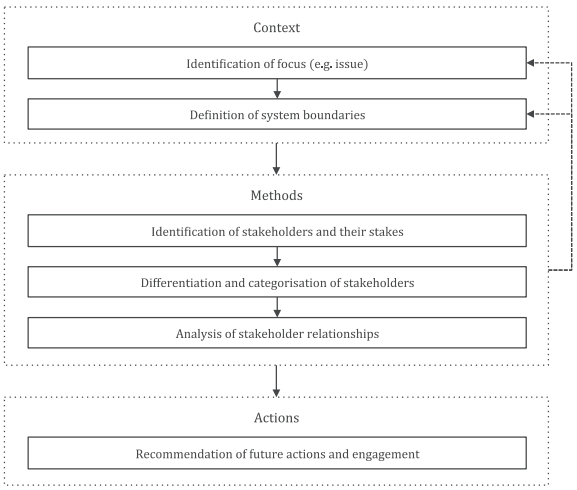

Fig. 2. Schematic representation of the stakeholder analysis applied (adapted from Reed et al. 2009).

CCA shifts the short-term reactive focus in DRM to a longer-term proactive focus as in CCA, i.e. from preparedness and response to prevention. Increasing the temporal scope of traditional DRM towards a longer-term perspective also broadens the portfolio of potential response measures, by linking risk management options to other policy areas in the broader context of sustainable development. The application follows an iterative "learning loop" process (Lavell et al., 2012), which enables the integration of new scientific and practical knowledge into existing CRM activities. The core of this iterative CRM framework, which requires participation of various societal stakeholders throughout, consists of four phases: (1) inventory, (2) climate risk analysis, (3) CRM measures and (4) CRM implementation. This is accompanied by two different but complementary cycles of regular monitoring and evaluation. The aim of CRM (Fig. 3) is to avoid negative climate-related effects or reduce and take advantage of opportunities that arise.

- Phase 1 refers to the evolving inventory of relevant instruments, scientific knowledge and data sources (e.g. data relevant to natural hazards, socioeconomic development, vulnerability damage data, sectors, regions, instruments) as well as regions and sectors at risk.
- Phase 2 concerns the (model-based and empirical) analysis of climate risks, comprising the biophysical aspects of climate-related hazards (natural trends, anthropogenic climate change signal) as well as socioeconomic aspects of exposure and (differential) vulnerability, taking into account the existing uncertainties and threshold values (changed risks and opportunities: "the new normal") as well as the individual risk perception of the social groups concerned. Furthermore, based on the risk layering approach, different occurrence probabilities and damage sizes are taken into account (events with a high probability of occurrence and low damage potential vs. events with a low probability of occurrence and high damage potential).
- Phase 3 deals with possible CRM measures to deal with "the new normal". In this step, measures are identified, prioritized and the action plan drawn up, based on the assessment of all three dimensions of climate-related risks: hazard, exposure and (differential) vulnerability (barriers and enablers). CRM measures shall be considered in a broader sustainable development context, highlighting the overall opportunities associated with climate-resilient risk development.
- Based on the results of phase 3, existing measures are revised in phase 4 and new measures for risk management (i.e. prevention, preparedness, response, recovery) are developed. With the integration of DRM and CCA, the focus of the implemented measures will shift from short-term reactive to longer-term pro-active.
- Monitoring and evaluation 1 ("incremental learning") takes place on a regular basis in order to further improve the methods used, the effectiveness of measures taken, the targets achieved and ultimately to further progress on managing climate risks.
- Monitoring and evaluation 2 ("transformational learning") takes place at a higher level. This longer-term learning process (5–7 years) reflects upon the overall CRM cycle and whether it needs to be fundamentally changed due to substantial changes in framework conditions, since the CRM system should be regarded as part of the overall socio-economic-ecological system.

3. Results

3.1. Stakeholder-mapping

For reasons of brevity, this paper only includes figures and tables (i.e. stakeholder map, activity matrix) for the case of flood risk. However, the descriptive sections on results, discussion and conclusion, refer to both flood and agricultural drought risk. The final stakeholder mapping for flood risk is presented in Fig. 4.

Drawing conclusions from the literature screening, the interviews and workshops (see Table 2 in the Appendix: thematic block "Position in CRM"), five stakeholders can primarily be assigned to flood risk, two to agricultural drought risk and seven to both climate-related risks. An overview of the key actors – primarily those with whom interviews were conducted – and their roles in CRM is provided in the Appendix (Table 3). The stakeholder descriptions include both the general areas of responsibilities and the CRM-specific aspects that fall within the areas of the stakeholders' activities.

The results of the stakeholder mapping show that the main institutions currently engaged with climate risks include ministries for water management/flood risk management, forestry, agriculture, the interior, civil protection, hydraulic engineering administrations e.g. flood control, meteorological services, unions or chambers for forestry, agriculture, insurance companies (public–private or private), other agencies and service providers. The stakeholder maps also demonstrate that flood- and drought-related institutions can be found at international as well as national, regional and local levels (see Fig. 4 for the case of flood risk). Some of these actors even span across geographical and institutional levels: in Austria, for instance, voluntary emergency and relief services are organized at national, regional and local levels, providing the main workforce in disaster situations (BMI (Ministry of the Interior), 2019; BMLFUW (Ministry of Agriculture, Forestry, Environment and Water Management), 2012). While this stakeholder mapping exercise focused mainly on public sector actors and institutions, we considered insurance as one of the key private actors in CRM. Moreover, public institutions are closely collaborating with private sector actors and thus the private sector actors are indirectly considered.

3.2. CRM governance – Stakeholder activities along the CRM cycle in Austria

Besides the stakeholder mapping, we also identified specific ongoing activities and responsibilities of stakeholders to determine potential gaps and overlaps between CRM-relevant institutions and to provide an overview of complementary activities and responsibilities (see Table 2 in the Appendix: thematic blocks "Activities in the field of CRM" and "Possibilities of influence and freedom of design"). Moreover, formal and informal interactions between the stakeholders were assessed, in order to generate insights into the current CRM governance arrangement in Austria. Activities and responsibilities were derived from the literature screening, interviews

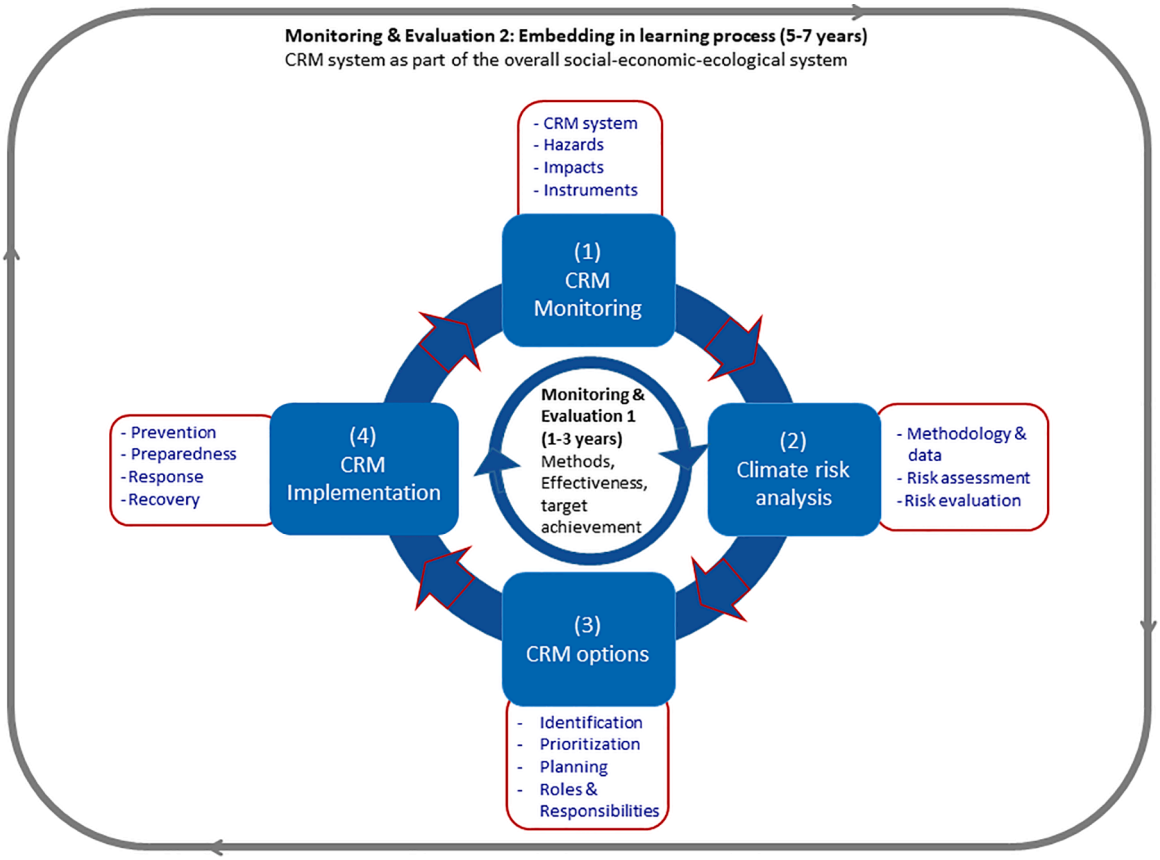

Fig. 3. CRM cycle (adapted, based on Schinko et al. 2017).

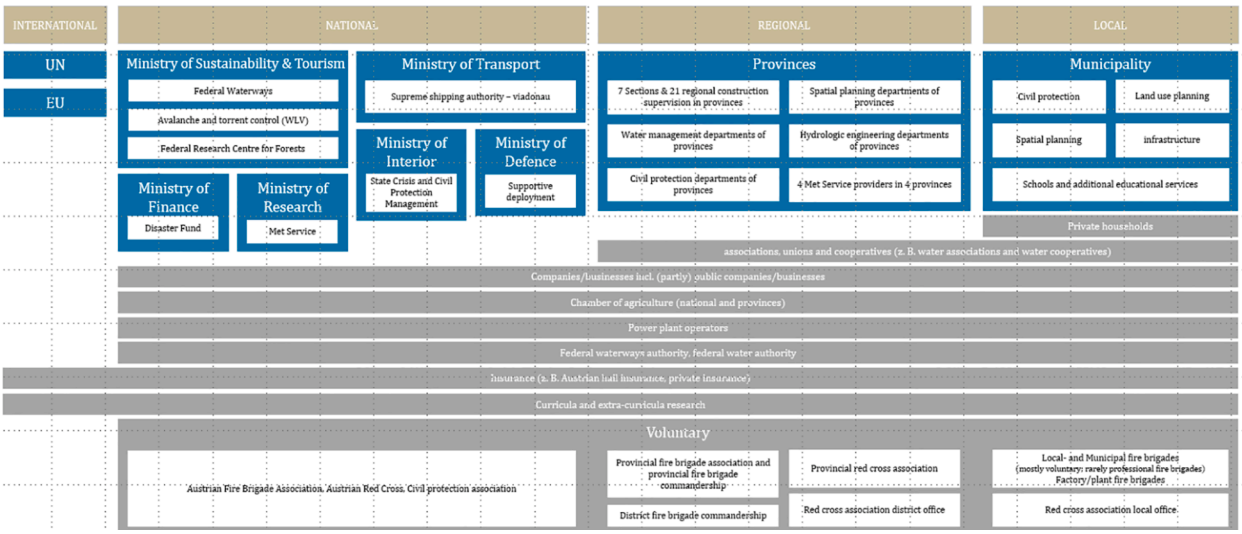

Fig. 4. Stakeholder map for flood risk (name of institutions based on 2018).

and workshops, and structured along the CRM cycle, resulting in a stakeholder activity matrix (see Table 1 (in Appendix) for the case of flood risk). In the activity matrix, each of the interviewed stakeholders (rows) is mapped against one of the four phases of the CRM cycle (columns). An inspection of the activity matrix allows identification of areas of high and low activity as well as of high and low institutional overlaps. While some activities, carried out by diverse institutions, seem to cluster in certain CRM phases (e.g. Phase 2 – Climate Risk Analysis), other phases remain blank, where only low or no CRM-related activity could be identified (e.g. Phase 4.2

– Preparedness). One interesting finding was that most interviewed stakeholders were aware of the activities of others (included in the activity matrix) but not at a very detailed level. Hence, discussing these activities in the stakeholder workshop was considered highly relevant by the participants.

3.3. Current situation of and requirements for CRM in Austria

The analysis of the stakeholder maps and activity matrices, which reflect a synthesis of the insights from the stakeholder interviews and workshops, revealed that a systematic approach to CRM is nevertheless lacking in Austria. In the following section, we outline in detail the status quo, gaps and recommendations articulated by the stakeholders (see Table 2 in the Appendix: thematic blocks "Practical implementation and processes in CRM", "Climate risk data" and "Early warning"). The presentation of results is structured according to the four phases of the CRM cycle (Fig. 3).

3.3.1. (1) CRM inventory

One of our main findings is that a holistic approach to CRM is still lacking in Austria. Stakeholders agree that a cost-effective and coherent overall strategy is required to minimize the risk of mismatches (in line with climate mitigation measures). In order for a comprehensive CRM system to be effective, it needs to take into account regional and local particularities. Stakeholders emphasize that the implementation of a CRM system must be seen as a gradual step-by-step process, meaning that a complete overhaul of the current DRM and CCA governance architectures will take time and a closer integration of DRM and CCA will likely only be implementable stepwise.

From a flood risk management perspective, climate scenarios (e.g. EUROCORDEX or e.g. ÖKS15[1]) are important tools and knowledge sources to better connect the two often separate areas DRR and CCA in practice, since both areas rely on this kind of data in their planning processes. In addition, interaction with other factors (e.g. socio-economic development) is considered highly relevant, since a large part of the increase in economic consequences of natural hazards observed in past decades has so far been mainly explained by socio-economic developments (see e.g. Bouwer 2019).

3.3.2. (2) Climate risk analysis

Stakeholders suggest that climate-related aspects (e.g. climate-related risks, adaptation and resilience measures) should be considered in the analyses of public budgets, e.g. in long-term budget forecasts. How the future financial burden will change is highly relevant in developing cost-effective strategies. In the context of the scientific analysis of costs of climate inaction, adaptation (-relevant) expenditures and benefits require significantly more attention in the future. The results must be prepared in an easily accessible manner and political actors should be more closely involved (e.g. for the coordination of model assumptions). Stakeholders also agree that there is room for improvement in the area of awareness raising.

Currently, instruments for hazard and risk analyses – in particular hazard maps – are either developed by crisis and disaster management institutions and/or purchased from third-party providers. For designing regulations and recommendations, external data and results from external projects are frequently used. This includes, for instance, historical damage data, runoff peaks, and hazard, risk and building maps. In the National Risk Analysis (NRA), to be drawn up every three years by members of the EU Civil Protection Mechanism (EU, 2019a), climate variability and current climate change is already explicitly taken into account. Insights from climate research are used in the NRA in order to enhance the robustness of the analysis by considering uncertainties regarding climate variability and future climate projections. Overall, the NRA provides information on both man-made and natural threats that Austria faces. Nevertheless, Austria's NRA, like that of most other EU countries, only considers rather short time-frames (up to the next 5 years). Longer time horizons would allow the effects of climate change to be captured more comprehensively and would lead to better-informed policies and more resilient development (EU, 2017).

The effects of climate change must be taken into account in the flood risk management plan from 2021 onwards (EU, 2019b). There are currently several cross-references to the national strategy for adaptation to climate change in the Austrian flood risk management plan, and current climate-related trends affecting floods are described. In the area of climate risk analysis, only classic (qualitative) risk assessment is currently used, identifying potential areas with danger to life and limb.

Certain basic strategies for disaster control, alarm plans and operational plans for flood protection (e.g. in case of dam overflows) are already in place, and further strategies need to be developed. Flood damage forecasting systems (internal or external), which allow identification of potential damage due to flooding, are deemed particularly important. Forecast models with an internal forecast period of 72 h and a publicly accessible forecast period of 48 h are already available.

Meteorological services that support climate risk analyses include biophysical data provision, data modelling and climate impact assessment. Socioeconomic data regarding exposure and vulnerability is currently not available at the same level of detail and quality as biophysical data in Austria. The areas of classic risk analysis include issues related to permafrost, glaciers and slope stability.

Since the UN climate conference in Paris (2015), the insurance industry has been trying to implement more comprehensive actions with regard to CRM, particularly in the area of information gathering and sharing, which go beyond the core task of insurance (risk transfer and ex-post damage compensation). In this context, the well-known and well-used reference in Austria is the HORA[2] project

[1] Climate Scenarios for Austria - https://data.ccca.ac.at/dataset/endbericht-oks15-klimaszenarien-fur-osterreich-daten-methoden-klimaanalyse-v01.

[2] https://hora.gv.at/eHORA.

(Natural Hazard Overview & Risk Assessment Austria). HORA is a digital hazard map developed by the state of Austria and the Association of Insurance Companies Austria (VVO), providing information about zones exposed to natural hazards, thereby providing important information with regard to the exposure dimension of flood risk. In HORA, for example, users can identify flood-prone areas with different return periods. The insurance industry has built up extensive expertise in recent years – the scientific status of climate research is well reflected in the insurance industry models.

Other governance levels can also play an important role, depending on the countries' governance and the responsibilities shared with other public authorities. For example, observation of the quantitative water cycle, expert services, and the preparation of hydrographic expert or protective water engineering reports and the operation of a hydrological information system.

3.3.3. (3) CRM measures

The existing flood control management body needs to manage the financing, planning and implementation of flood protection measures and water management (e.g. low water and drought). At a strategic level, the bodies have been and will be involved in the Austrian strategy for adaptation to climate change. When developing flood mitigation measures, for example, cost-benefit analyses are carried out prior implementation. Stakeholders agree that an additional crisis and disaster management body, responsible for coordinating measures that are taken at different governance levels by different actors, in the case of national and international events, is needed.

3.3.4. (4) CRM implementation

(4.1) Prevention

Currently, crisis and disaster management focus on disaster preparedness and response rather than on prevention. In terms of education, however, cross-organisational training and funding are offered.

For financing preventive infrastructure (e.g. flood protection structures), the existing Disaster Fund might be a potential financial resource. Stakeholders emphasize that prevention planning also needs to include trends such as population development, urbanisation or others, especially when designating risk zones (e.g. areas of potential significant flood risk).

(4.2) Preparedness

Online applications for crisis and disaster management, e.g. KATWARN Austria, have been made available in recent years. This system transmits information and warnings from the authorities to mobile devices, depending on location, event or type of risk. These applications supplement the existing and more traditional warning options, such as sirens, loudspeakers and the media. Emergency services have dedicated access to these applications, allowing them to access more detailed data and extended functionality compared to standard users.

In the preparedness phase, early warning systems (e.g. storm, large amounts of rain and snow, thunderstorms, hail and heat) which utilize impact-oriented forecasting including satellite information, are considered of high importance. These warning systems are accessible to the general public as well as to specific user groups.

(4.3) Response

The body for disaster preparedness and response is primarily active in event-related management, as a hub and contact point for enquiries and support for the operational area. On-site, volunteer emergency and relief services provide the main workforce in directly responding to natural disasters.

(4.4) Recovery

Stakeholders emphasise that instruments for financing disaster recovery need to be in place, especially for coping with extraordinary catastrophe losses and allowing for building back better. Individuals who suffer damage from natural disasters should be encouraged to invest in preparedness and private insurance to transfer the risk and ex-post damage compensation from public to private actors.

Since the Paris climate conference, the insurance industry has tried to incorporate more comprehensive measures in the field of CRM to support more holistic resilience and vulnerability management. In general, the insurance industry is increasingly focused at the individual (building) level. Information campaigns, for instance, are expected to encourage households to take precautionary action.

3.3.5. Monitoring and evaluation 1 (1–3 years)

In flood control management the priority should be on activities that are continuously adapted to the current state of knowledge and the current understanding of risk and capacity to adapt. These include, for example, a central building and apartment register, outbuildings, other usage units and construction projects.

The event documentation and processing of relevant flood events (e.g. the flood disaster 2013) in the form of monitoring is deemed particularly important. Such information can inform the implementation of renovations and preventive measures as well as follow-up planning (e.g. renovation or changes to protective structures). In addition, GIS maps detailing the flood lines, are considered essential.

Moreover, stakeholders add that continuous measurements of stop lines need to be carried out.

Recognising and using "windows of opportunities" (e.g. shortly after a flood event) is considered important in bringing about the necessary changes, helping flood-prone areas to become resilient. After a hazard event, a short time window opens in which (local) actors are presumably more willing to take adaptive actions. Lessons could be learned from existing good (and bad) practices and applied to natural hazard management.

3.3.6. Monitoring and evaluation 2 (5–7 years)

While stakeholders emphasized the need for better aligning DRM and CCA in Austria, they argued that a complete implementation of an integrated and comprehensive CRM framework in Austria will likely take years. This reflects the longer-term time horizon (5–7 years) of the transformational learning process indicated in Fig. 3.

4. Discussion and conclusions – The way forward towards operationalizing CRM in Austria

Based on the results presented above, it is evident that the multidimensional nature of interrelating CCA and DRM requires a more systemic, comprehensive and integrated approach at the intersection of CCA and DRM, seeking to better understand the nature of interacting systems. Comprehensive CRM can provide that entry point. In the following, we relate our findings back to our four initial research questions and discuss them in relation to the existing literature.

4.1. What are the current governance structures at the intersection of DRM and CCA in Austria?

At the national level, the first activities to integrate climate change aspects into the DRM practice are already underway in Austria, as illustrated, for example, by the latest revision of the national flood risk management plan. Those activities included relate to the CRM inventory phase of the CRM cycle (see Fig. 3).

In the area of climate risk analysis, particularly with respect to flood risk, there are already numerous forecasting tools that support authorities in identifying and analysing risk drivers. This is typically managed by administrative units, in the form of outsourced activities (commissioning external experts). However, possible future climatic and even more so socio-economic developments affecting societal exposure and (differential) vulnerability to climate-related risks (e.g. population development, urbanization, and aging) are not yet sufficiently taken into account and should be included in future climate risk analysis. The "Geon" approach for Austria for quantitative risk and vulnerability analysis based on homogeneous spatial units (Kienberger et al., 2016, Lang et al., 2014), was rated as particularly promising by the participants of the second stakeholder workshop. Moreover, one of the most relevant topics for all actors is the coherence in the inclusion of uncertainties in current and future physical and socio-economic data and modelling approaches.

Especially in the area of flood risk management, Austrian stakeholders have begun to take future climate risks into account and the first preparatory work in terms of planning has been carried out to drive forward measures. For example, the potential consequences of climate change must be taken into account in the flood risk management plan from 2021 onwards. Further emphasize should be put on considering potential flood risk in planning and implementing flood-resilient climate change mitigation investment projects.

In the area of drought risk management, there are currently hardly any or only incomplete approaches that consider future climate change. The focus of this research with regard to drought risk was on agricultural drought, thus other drought and heat affected stakeholders were not included in the stakeholder mapping or stakeholder workshops. We suggest to broaden the scope in future work on hydrological and meteorological drought, its relevance for e.g. nature conservation and biodiversity, and to involve respective stakeholders' in future participatory research. Heat waves and related health consequences were not at the core of this research effort either but would also constitute a fruitful area for future research.

In the CRM implementation phase, various flood risk management measures have already been implemented by Austrian authorities to adequately manage current flood risk, but there is potential to take future climatic and socio-economic changes into account in the design of these measures within the monitoring and evaluation 1 phase. In the area of drought risk, the consideration of CRM is still in its infancy. Here, the current focus lies on the more traditional DRM activities raising awareness and providing early warnings, and the link to CCA is currently still very weak.

In our research, the focus was mostly on stakeholders from the public sector. We suggest to broaden the focus in future research also on the potential role of citizens and the private sector at the intersection of DRM and CCA.

4.2. How closely aligned are these areas in the Austrian decision and policy making practice?

Established natural hazard and disaster risk management focuses on coping (including prevention, preparedness, response and recovery) with climate-related risks in Austria due to natural climate variability, but there is not yet a concrete link to CCA practice. Currently, CRM does not exist in Austria's institutional setup or across departmental boundaries (at least not explicitly, as there are no separate departments or an appropriate lead department that pursue a dedicated CRM approach). However, new approaches are being developed to better align these two domains, for example, via the "natural hazards and climate change check" for Austrian municipalities, which serves as a new tool for awareness-raising and prevention at the municipal level (Lexer et al., 2018). This tool is based on and has been developed via a strong cooperation between several national and sub-national institutions.

Awareness of the need for greater integration between natural hazard management and climate change adaptation – and thus between (natural) climate variability and (anthropogenic) climate change as a driver of the hazard potential – seems to be present and

efforts are being made in some institutions (at least by individual staff members) towards a more comprehensive CRM. These developments are also reflecting the aims of global agreements, namely the Sendai Framework for Disaster Risk Reduction towards risk management and the Sustainable Development Goals. Activities such as the workshops presented here therefore allow stakeholders to network, exchange information and to eventually kick-off concrete collaboration at the intersection of DRM and CCA. These efforts are now slowly beginning to be reflected in the activities of different actors by considering climate variability and climate change risks in recent planning processes e.g. forest fire prevention, and the development of the new flood risk management plan.

4.3. How can the activities be aligned more closely?

Based on our findings derived from the stakeholder engagement process, the following steps are necessary to further develop CRM in Austria and to successfully implement it in the long-term:

- Taking climate change into account as a driver of risks within natural hazard management is currently still in its infancy (e.g. a simple surcharge for assessment bases). We therefore recommend in-depth cooperation across the current boundaries between climate change adaptation and natural hazard management. This could be operationalized by establishing a legally anchored national climate risk council in order to create the missing decision-making structures and to develop an interface to political decision-making. This is also beneficial given the current lack of overview of the activities in the individual sub-areas (ministries, departments, agencies, research institutions, etc.). Prior to our study, there was no comprehensive assessment of governance and decision-making structures in the context of CRM done.
- One starting point could be improving links between risk assessments from related policy fields, such as National Risk Assessments (NRAs). NRAs and Climate Change Impacts and Vulnerability (CCIV) Assessments have some elements in common and such synergies can be capitalised on. Moreover, NRAs, which assess a longer time horizon, would allow more complete capture of climate change effects and thus lead to better-informed policies and more resilient development. Thus, we recommend streamlining and coordinating efforts between different kinds of risk assessments, by increasing coherence and complementarity among policy areas.
- The implementation of a comprehensive CRM, at the interface between DRM, including natural hazard management, and climate change adaptation, currently only takes place to a limited extent in practice. An important reason for this is the often unclear assignment of roles and responsibilities in practice. The "role play simulation CRM" (Lintschnig et al. 2019), which was presented at the second workshop, was confirmed by the participants as an important tool for closing implementation gaps and coordinating an integrated CRM on the regional to local scale. Moreover, it was rated as highly useful method for clarifying the roles and responsibilities in CRM in a cooperative situation. In addition, the role-play simulation enables a better understanding of the complex risk and decision-making context, as well as the effectiveness and possible positive and negative effects of risk management measures. The simulation leads to a better mutual understanding, promotes cooperation between the actors and enables the joint prioritization and 'bundling' of measures. We therefore recommend to clearly define the roles and responsibility in CRM in Austria, ideally by applying participatory tools such as role-play simulations.
- The current lack of cross-examination of various climate-risks requires a governance capability, at an appropriate level with the necessary authority and resources to carry out the required functions, focusing on cross-cutting issues. One suggestion that emerged from our stakeholder consultation process was to set up by law a national risk council and climate change could be categorised as one of the risks considered. One of its specific tasks could be to create a periodic risk report.
- A particular challenge is the uncertainty inherent in socio-economic and climate data as well as socio-economic and climate scenarios. This is perceived partly as an obstacle or block to decision-making. It is therefore important to have solid and reliable data to enable mainstreaming of climate risks within DRM and CCA. Since uncertainties will always exist, it is important to provide information on those uncertainties as well as respective guidance that can inform about the data and information use, including those associated uncertainties that are likely to be more critical. The proper inclusion of uncertainties in appropriately designed and delivered risk assessments can result in more robust decisions. Also the need for further, in-depth scientific studies in the field of climate change consequences is thus emphasized by many interview and workshop participants. A CRM approach would support this – the uncertainties are taken into account, but without categorically excluding climate change considerations. Rather, this approach enables a proactive take to climate risk and an iterative development of the current approach across existing departmental boundaries.
- The focus of the Disaster Fund in the private sector is currently only on recovery. According to the stakeholders, the fund should ideally also be used to finance private sector preventive action like building better and retrofitting to enhance resilience. Both in numerous interviews and in the workshops, modification of the Disaster Fund Act was proposed in such a way that it increases incentives for private precautionary measures. The further development of the Disaster Fund in combination with insurance models – as part of a public–private partnership – was also discussed in the workshops, going into the direction of a disaster resilience fund.

4.4. What are universal lessons for CRM that can be learned from the Austrian case study?

As stated by (Howes et al., 2015), the lessons learned from the Australian case study on CRM clearly refer to jointly developing a shared policy vision, and calls for adopting multi-level planning as well as highlighting the need of further networking organizations.

One of the current major challenges in CRM is the lack of awareness of climate change and climate risks among the population. Raising awareness and hence increasing acceptance of response measures requires, amongst others, a better understanding of the

added-value of investments in building resilience. This is of central importance insofar as the implementation of a climate risk-aware policy depends heavily on broad social support from the general public. Raising awareness has been proposed as a possible way to increase acceptance of risk-reducing measures among the population. What is needed is a "positive picture of the future" to create a foundation for wider acceptance. Such a positive picture can be supported by emphasizing the positive overall development opportunities in which climate risk management is integrated.

A cross-examination of various risks beyond the area of climate risk is also required. Beyond strengthening existing institutions, there may be a need for new initiatives or bodies to fulfil key functions, or structural changes to risk management and governance approaches may be required to create an enabling environment for cooperation. New institutions or a superordinate body (e.g. a national risk council), for example, could be established which acts specifically as a boundary partner, connecting relevant actors, innovating by developing new tools and approaches to support decision-makers, and by providing resourceful knowledge management tools. One of the specific tasks of a national risk council could be to create a periodic risk report going beyond existing natural hazard risk assessments by (1) embedding climate-related risk in the broader social-economic-ecological system, (2) explicitly focusing on anthropogenic climate change as major risk driver next to natural variability and socioeconomic development (exposure and vulnerability), and (3) reflecting on critical uncertainties associated with future climate change and socioeconomic developments. In setting up this national risk council, it is important to develop structures and processes that allows for effectively linking the national governance level to lower levels of governance as well as for a sectoral integration of climate-related risks with other risks. Discussing these design principles goes beyond the scope of this paper but constitutes a fruitful area for future research.

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

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