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Prospects and challenges of transdisciplinary research approaches for managing and communicating climate-related risks

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Prospects and challenges of transdisciplinary research approaches for managing and communicating climate-related risks

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Abstract

The Sendai Framework highlights the need for closer collaboration across society to manage climate-related risks more effectively, for which the UNDRR set up a Stakeholder Engagement Mechanism. Fostering procedural justice through stakeholder engagement and participation is regarded key for enhancing understanding between stakeholder groups involved in disaster risk management (DRM) and climate change adaptation (CCA), reducing conflict, and promoting cooperation towards a more just and effective risk management. This study discusses insights, lessons learned, opportunities and challenges in the development and implementation of stakeholder focused, transdisciplinary research approaches in the context of managing and communicating climate-related risks more effectively. We find that collaborative research approaches (1) enable diverse societal stakeholders to better understand the interacting dimensions of risks as well as each other's interests and needs in addressing such risks; and (2) engage societal stakeholders beyond traditional policy and decision-making communities in informed and inclusive public debate around challenges and solutions to climate risk management (CRM).

Keywords: Climate risk management; participatory research; stakeholder engagement; procedural justice

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Introduction

While there are still considerable uncertainties regarding the exact contribution of anthropogenic climate change to disaster risk and related impacts, increasing losses from extreme events – globally and at national levels – have emphasized the need for addressing climate-related risks[1] at the intersection between disaster risk management (DRM) and climate change adaptation (CCA) (IPCC, 2012 and 2014; UNISDR, 2015). Linking these two overlapping policy fields has been suggested as crucial for a more effective management of climate-related risks, and hence to reduce negative impacts on the natural environment, human society, and economies. The term comprehensive climate risk management (CRM) has been coined for this coordinated approach (Chambera et al., 2014; IPCC, 2014; Jones et al., 2014). Watkiss et al. (2014) identified CRM as a blueprint for early action on climate-related extremes—addressing the current adaptation deficit in the short term, and mainstreaming climate change into medium-term climate adaptation. Mechler et al. (2014) suggested that CRM means comprehensively reducing, preparing for, and financing climate-related risk, while tackling the underlying risk drivers, including climate-related and socio-economic factors.

Such an integrated narrative is in line with international disaster risk and climate policy frameworks as well as the UN's Sustainable Development Goals (SDGs). The Sendai framework (UN, 2015a) emphasizes synergies between understanding risk, strengthening risk governance, investing in resilience and enhancing preparedness. The Paris Agreement (UNFCCC, 2015) stresses the need to foster comprehensive risk assessment and management in order to deal with climate-related risks, and Target 13.1 of the SDGs seeks to "strengthen resilience and adaptive capacity to climate- related hazards and natural disasters in all countries" (UN, 2015b).

Despite these calls for a stronger alignment between DRM and CCA under the umbrella of comprehensive CRM, these policy domains often remain uncoordinated inpractice. The Sendai Framework (UN 2015a) suggests that a more effective and coordinated management of (climate-related) disasters hinges on closer public and private collaboration. However, the respective and collective roles and responsibilities of stakeholders in CRM are blurry and subject to negotiation: many risks affect private as well as public goods; legislation and policy practice in many countries have evolved over the years towards a partly explicit, partly implicit understanding of each actor's role in preventing, financing, responding to or recovering from risks and events linked to natural hazards (e.g., Hallwright and Handmer, 2021; Leitner et al., 2020); actions undertaken by one actor may limit or widen the room to maneuver of, or the actions expected from other actors, and may encourage inaction or free-riding behavior. These roles are being discussed and renegotiated continuously. To promote coordination, information exchange and harmonization between stakeholder groups (scientists, policy makers, decision makers, civil society organizations, private sector, households), the UN Office for Disaster Risk Reduction (UNDRR) set up the Stakeholder Engagement Mechanism (SEM) (UNDRR 2020). Overall, the SEM aims to leverage the convening, advocacy and

[1] The term climate-related risk is often used to refer to the potential for adverse consequences of a climate-related hazard (including extreme weather and climate events) on lives, livelihoods, health and well-being, ecosystems and species, economic, social and cultural assets, services (including ecosystem services), and infrastructure. Climate-related risk results from the interaction of vulnerability (of the affected system), its exposure over time (to the hazard), as well as the (climate-related) hazard and the likelihood of its occurrence. IPCC (2018)

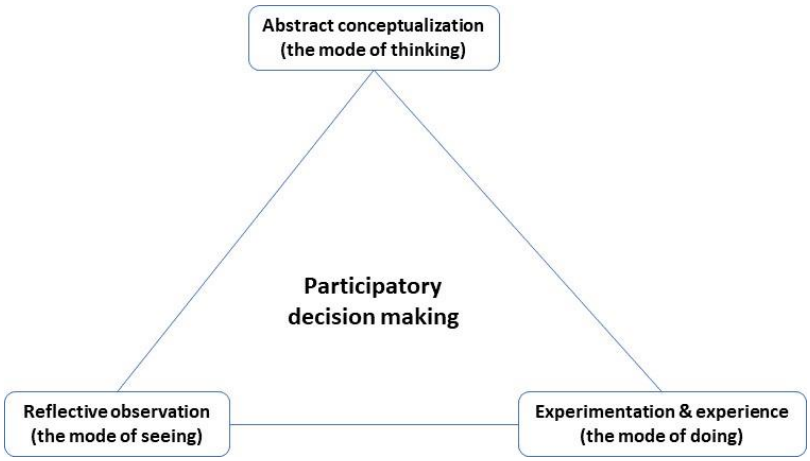
implementing power of participating stakeholders in support of the implementation of the Sendai Framework and the integration of DRR into the broader 2030 Agenda. It defines its mission as “bringing case studies, lessons learned and expertise from the ground to the attention of global and regional policy processes to enhance implementation of risk reduction action” (UNDRR, 2020). This important effort, notwithstanding the challenges of meaningfully incorporating the immense diversity of stakeholder experiences, knowledge, and worldviews into our understandings of disaster risk and related measures, present significant obstacles to both procedural justice and effective CRM implementation, i.e. comprehensively reducing, preparing for, and financing climate-related risk, while tackling the underlying risk drivers, including climate-related and socio-economic factors.

Transdisciplinary research, which connotes a research strategy that not only crosses disciplinary boundaries but also transgresses between science, policy and society, is called upon to generate appropriate participatory methods and tools for stakeholder engagement in CRM decision making processes (Solinska-Nowak et al., 2018; Challies et al., 2016), in order to disentangle the complex distribution of competencies and responsibilities, while at the same time considering different worldviews (Verweij, 2011) and risk perceptions of various stakeholder groups or individuals. Participatory decision-making is expected to result in “better decisions and plans, improved implementation and compliance, more beneficial social outcomes, greater legitimacy of planning processes and, ultimately, fewer negative environmental impacts as compared to top-down, administrative decision making” (Challies et al., 2016, p. 2). Participatory decision making is a core element to the principles of good governance[2] for human development as proposed by UNDESA (2012). Additionally, the World Meteorological Association (WMO, 2006) identifies potentially strong merits of participatory decision making. Traditionally, decision making was thought to consist mainly of intellectual effort, or thinking, which draws on science, planning, facts, and verbal capacities. However, according to Mintzberg and Westley (2001), there are at least two other modes that can be employed. One is seeing, which involves art, visioning, imagining, and the visual representation of ideas. The other is doing, which makes use of craft, learning through experience, venturing, and the visceral (Figure 1). This claim can be further supported by the experiential learning theory (Kolb 2014), which posits that the process of learning (understood broadly as the totality of human experience) should include and balance: abstract conceptualization (the mode of thinking), reflective observation (the mode of seeing), as well as active experimentation and concrete experience (the mode of doing).

The aim of this report is to present useful insights from developing and applying participatory approaches for stakeholder engagement in CRM across four continents. Rather than suggesting these approaches as exemplary models of success, we reflect critically on our efforts to draw out important lessons learned about what has worked well, what challenges have been encountered, and what can be focused upon moving forward to support just and meaningful stakeholder inclusion and participation.

[2] In this paper we understand governance as the institutions, rules, conventions, processes, and mechanisms by which policy is made and implemented. The principles of good governance comprise participation, representation, fair conduct of elections; responsiveness; efficiency and effectiveness; openness and transparency; rule of law; ethical conduct; competence and capacity; innovation and openness to change.

Figure 1. The elements of participatory decision making and learning. Own visualization based on Mintzberg and Westley (2001) and Kolb (2014).



The experiences gathered through these participatory processes confirm that participatory stakeholder approaches are crucial for improved CRM decision making. However, it is important to recognize that what is considered as stakeholder involvement and participation varies greatly across the myriad of challenges and contexts in which it occurs and that some approaches will support effective stakeholder engagement and procedural justice (i.e., the ability of people affected by decisions to participate in making them; Ottinger, 2013) much more than others.

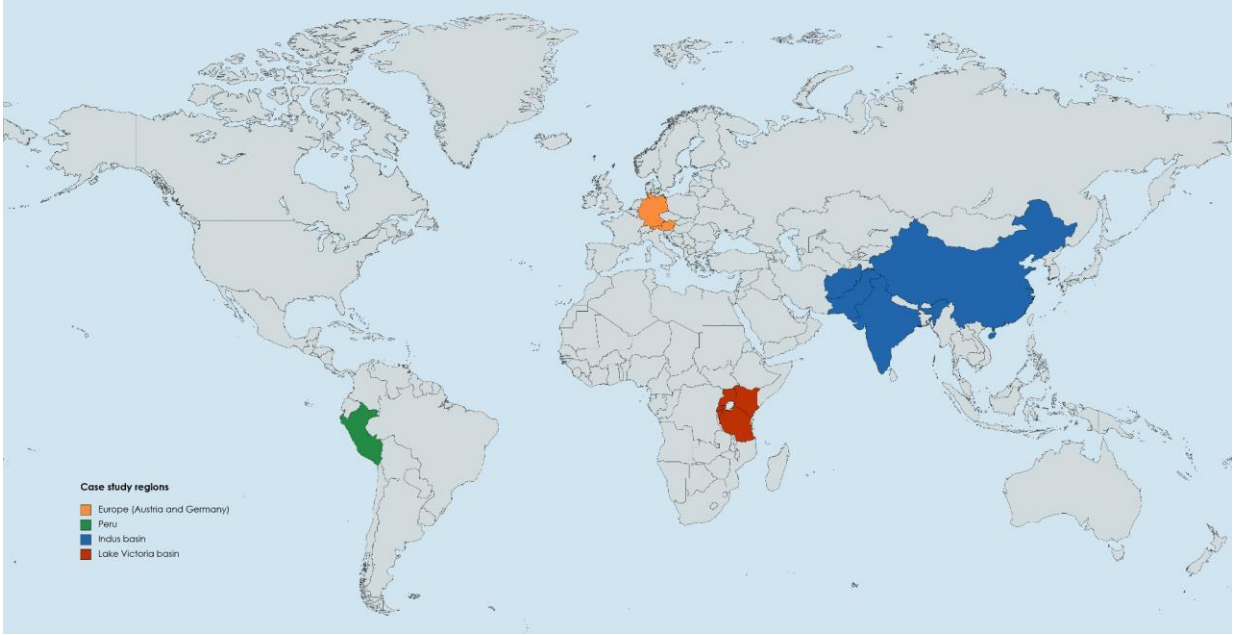
We first describe the comparative case study methodology employed in this paper. The study will then describe and discuss the recent examples of transdisciplinary research on managing and communicating climate-related risks (such as flood and drought), highlighting innovative aspects such as the conceptualization of scientific research and its impact chains, changing roles/expectations of researchers and stakeholders, and related methodological advancements made in making science- based information accessible, relevant and useful. We then outline key remaining challenges for effective use of scientific information and major motivating factors behind the current surge of interest among research communities to engage deeper with end-users. Our results will support decision makers in identifying and developing effective stakeholder engagement processes for tackling various climate-related risks in diverse contexts.

Methodology

In this paper, we conduct a comparative case study analysis based on recently completed or ongoing transdisciplinary research engagement across four continents (Figure 2). The case studies resemble the following five research projects that develop and apply diverse stakeholder-focused, collaborative research approaches in the context of capacity-building activities and developing policy options for tackling climate- related risks:

- Identifying roles and responsibilities in managing risks at the intersection of disaster risk reduction (DRR) and climate change adaptation (CCA) in **Austria**, focusing on riverine flooding and agricultural drought.
- Analyzing responsibility sharing and risk communication between public actors and private actors in **Austria and Germany** to better understand how the current governance arrangement enables the implementation of property level flood risk adaptation measures.
- Exploring transboundary and cross-sectoral risks related to water, energy, and land, and co-designing with the stakeholders, future pathways for the **Indus Basin** and its riparian countries.
- Identifying and communicating systemic dimensions of flood risk and disaster risk management through participatory engagement with civil-society stakeholders and DRR experts in **Peru**.
- Enhancing policy relevance of scientific knowledge in **East Africa** to strengthen resilience in scaling sustainable rice and fodder production.

Figure 2. Overview of case study regions covered in this paper.



We build on a framework developed by Aubert et al. (2019) in the context of serious gaming approaches for sustainable water governance to analyze and synthesize similarities, differences, and patterns across these five cases of collaborative research approaches (see section 4). This framework suggests the following four questions to be most important for comparatively analyzing different game-based approaches:

"*What*?", i.e., the topic of the game-based approach; "*Why*?", i.e., the specific purpose of the approach; "*Who*?", i.e., the actors participating in the approach; "*When* and *where*?", i.e., the temporal and spatial contexts of the case and the process. Since our case studies cover a broader range of participatory methods than only game-based approaches, we add "*How*?", i.e., the specific participatory approach employed, to this list and substantiate this question by distinguishing between Mintzberg and Westley's (2001) three modes for participatory decision making (*thinking*, *seeing*, and *doing*).

Case studies insights

Europe

Identifying roles and responsibilities in CRM in Austria

Problem setting and objectives

Austria has been subject to recurrent flooding and was hit by large-scale events for example in 2013, which led to substantial losses (estimated at EUR 0.9 billion; BMI, 2014). As one of the first in-depth national assessments of climate change worldwide, following the comprehensive assessment approach taken by the IPCC reports, the Austrian Panel on Climate Change (APCC) showed that warming in Austria is stronger than the global average, leading to increasingly severe risk and the need to upgrade adaptation efforts (APCC, 2014). As a follow-up to this APCC report, a country-wide economic assessment of the costs of climate change in the absence of further climate policy was conducted in 2015, demonstrating large cost implications of unmitigated climate change (i.e., costs of inaction) for public and private actors already today (Steininger et al., 2015). Also, in 2012, the Austria Council of Ministers adopted the national adaptation strategy and action plan, which was co-generated with a large set of stakeholders and identified many options, which have been prioritized in terms of their costs, benefits and potential to reduce risks and impacts (Federal Ministry for Sustainability and Tourism, 2018). These recent developments highlight the need for further aligning CCA and DRM agendas in practice and planning at the sub-national, national, and international levels.

The overarching objective of the Austrian research project RESPECT (Responsibility and Risk: Operationalizing comprehensive climate risk layering in Austria among multiple actors) was to support the implementation of comprehensive CRM in Austria, by working closely with relevant stakeholders at national, subnational and local levels to close the gap between research, practice, and policy. More

specifically, in the context of transdisciplinary research the research project pursued the identification and allocation of roles and responsibilities in CRM through role-play simulations. Against this background and objectives, we set out to answer the following research questions: i) What is an appropriate method for identifying and allocating roles and responsibilities in CRM in Austria, and ii) how can it be applied in the context of managing current and future flood risk?

Participatory method employed

Role-play simulations have been suggested to streamline the worldviews and actions of diverse stakeholders on various levels of governance (Rumore et al., 2016). By switching to the roles of other actors, players develop a reciprocal understanding and acceptance of the interests and resources of their co-players. Hence, role-play simulations can provide new avenues for communities to adapt to climate risks by building capacity for collective responses (Rumore et al., 2016). Given that role-play simulations and similar serious games have been proven valid in complex policy- making contexts, they may also prove an effective tool in CRM (Haug et al., 2011; Mayer, 2009; Parson, 1997).

Compared to the traditional policy discourse, a role-play simulation has ample potential for bridging gaps in appraisals of risks and coping options between public, private and civil society actors. Besides clarifying technical-physical risk issues, a role-play simulation captures and, to some extent, clarifies the social-political complexities of CRM (Mayer, 2009). Profound differences in risk judgment between (presumably) knowledgeable experts and (presumably) naïve laypeople are among central reasons why efforts in risk communication often remain ineffective (Bostrom, 2003, 1997; Rowe and Wright, 2001; Sjöberg, 2001; Slovic, 1987).

Thus, leveraging the transformative potential of this method for CRM, two role-play simulations (one for flood risk and one for drought risk) have been developed, tested, and implemented in two case study regions in Austria. Drawing on social learning (Pahl-Wostl and Hare, 2004; Reed et al., 2010), the key objective of the role-play simulations was to formulate an aligned understanding on how local risks, roles and possible actions should be shared between multiple societal actors.

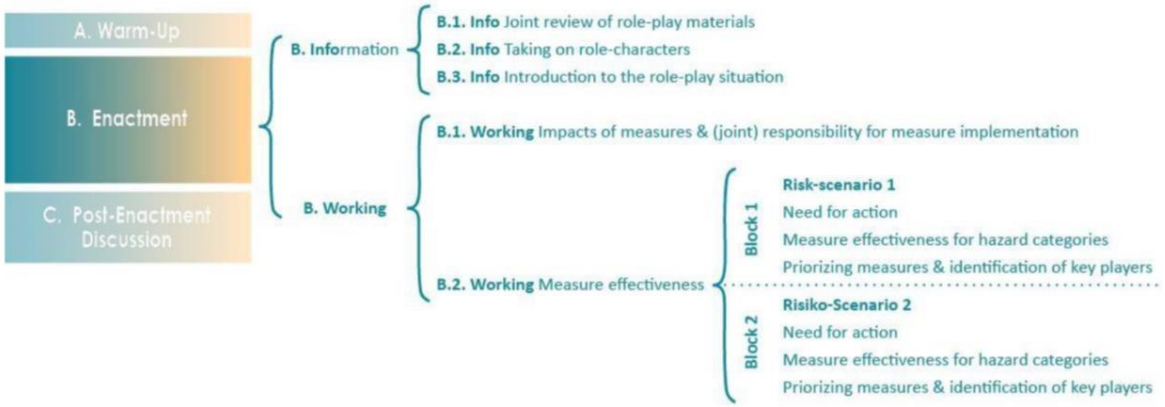
The RESPECT role-play concept (Lintschnig et al, 2019) employs a risk layering approach in combination with possible future risk scenarios for floods and droughts. Risk layering involves identifying efficient and acceptable interventions based on the recurrence of hazards and allocating roles and responsibilities to reduce, finance or accept risks (Mechler et al, 2014). The future risk scenarios are integrated in the role-play concept in the form of storylines that were co-developed with key stakeholders in the region, building on the most recent climate and socioeconomic data for the study region. Storylines provide narrative descriptions of plausible pathways that lead to the development of future climate-related risks. Possible futures are mainly described by words and not by numbers, tables or graphs can be too complex for lay people (Alcamo, 2008) and they have been recognized as valuable tools for communicating climate-related risks (Shepherd et al., 2018). Nevertheless, quantitative results substantiate the developed storylines.

The role-play (Lintschnig et al, 2019) requires players to work out responsibilities related to adaptation measures for public and private sector actors and to elaborate the effectiveness of the measures regarding their risk mitigation potential for two contrasting hazard categories that differ in their return period (risk layering). Role-play simulations operate in a “no-penalty zone” (O’Sullivan, 2011) which “looks like, seems like, but is not actuality” (Heathcote, 1991). Therefore, participants are permitted to test attitudes and decisions without risking real consequences. Furthermore, they experience the decision process that is incorporated in the RESPECT role-play concept not from their personal point of view, but from the perspective of another stakeholder. Given these opportunities, role-playing is widely accepted as a powerful method for changing perspectives and behaviors.

As proposed by Wohlking & Gill (1980) and illustrated in Figure 3, the RESPECT role-play is

structured in three functional phases. In the beginning (A), the participants are introduced to the role play setting in a warm-up phase before (B) the participants step into their roles and the major part of enactment takes place. Afterwards, (C) the players leave their roles and the role-play is completed by debriefing and discussion.

Figure 3. Overview of the role-play workshop concept and procedure in the enactment phase. Source: Lintschnig et al. (2019)



Insights and lessons learned

Both role-play workshops were systematically documented and assessed with five different instruments:

1) A documentation of the workshops by audio recording to assure that discussions and arguments can be reconstructed afterwards.
2) A documentation of the results of all tasks in the workshops by collecting the working sheets and flip charts that have been used by participants during the workshop.
3) Oral reflection and discussion of the role-play concept and components with participants and role-play personnel.
4) Pre- and post-role-play standardized questionnaires to assess the effect of the role-play on risk attitudes and risk behavior (15 questions).
5) A feedback form with both open ended (n = 7) and closed (rating scale, n = 10) questions. The questions were related to the design, implementation and practical usefulness of the RESPECT role-play simulation.

Overall, 14 (out of 17) participants returned the feedback form. The results indicate that the role-play materials and tasks were mostly assessed as “understandable” or “rather understandable” (5-graded rating scale: 1 = “understandable”, 2 = “rather understandable”, 3 = “neither nor”, 4 = “rather not understandable”, 5 = “not understandable”). The applicability of the role-play concept to elaborate on different fields of stakeholder responsibility, risk management measures and their potential effects was also mostly assessed as “appropriate” or “rather appropriate” (5-graded rating scale from 1 = “appropriate” to 5 = “not appropriate”). The role play methodology was regarded as particularly appropriate for developing a better understanding of other stakeholders points of views. 13 participants (out of the 14 who returned their feedback form) indicated that they would recommend this workshop to stakeholders in other communities. The most diverse feedback was given in regard to the role-play simulation feature of taking on a specific role character during the role-play simulation and thus to assess

things from a different perspective than his/her own. Four respondents chose “I found it easy”, four “I found it rather easy”, two “neither nor”, and four “I found it rather hard”. Different reasons were given by participants who had difficulties, e.g., the role was a controversial one or there was too little background information provided on the role.

Based on these experiences and lessons learned from developing and testing role-play simulations in the context of managing climate-related risks, we can conclude that this particular participatory methodology can be useful for identifying and allocating often unclear roles and responsibilities in CRM. The participants’ feedback highlights the strong potential of role-play simulations to overcome conflicts and misunderstandings in CRM policy and practice, by fostering a better understanding of other stakeholders’ points of views.

Risk communication for fostering property level flood risk adaptation measures in Austria and Germany

Problem setting and objectives

Due to high damages caused by hydro-meteorological events (Jongman et al., 2014; Munich Re, 2018; Blöschl et al., 2019), it becomes increasingly apparent that private actors (e.g., homeowners, occupants, users) must play a more central role in flood risk management (FRM) (Kaufmann & Wiering, 2017), such as the implementation of adaptation measures at property level (Joseph et al., 2015; Attems et al., 2020a). These property level flood risk adaptation (PLFRA) measures include wet flood-proofing (controlled flooding and the adaptation of interiors), the avoidance of flooding (e.g. stilts, floating structures, building on elevated ground), dry floodproofing (e.g. watertight basement windows, etc.), barrier systems and emergency measures. In many cases, simple measures can reduce considerable damage to existing buildings and interior (Kreibich et al., 2017). Therefore, PLFRA measures have been proven to be cost-efficient and effective to reduce damages caused by floods (Kreibich et al., 2012; Kreibich et al., 2015).

While private actors are increasingly encouraged to actively engage in FRM, state (public) responsibilities in FRM span across all three governmental levels (local, regional and national) due to the federal system of the Republic of Austria (Weber, 2018; Rauter et al., 2019). Funding mechanisms as well as the regulative framework are competences of the state (national level), while planning, funding and partly, the implementation of measures are the tasks of the provinces (regional). At the local level, municipalities are concerned with funding and the implementation of measures. However, when it comes to the implementation of PLFRA measures, roles and responsibilities are often unclear, prompting two recent research projects to clarify them, namely SHARED (Adaptation strategies and policy implementation for sharing responsibility in managing mountain hazards) and FLOODLABEL (A smart tool for governance towards flood resilient cities).

The development of sharing responsibilities between different actors is related to the concept of integrated FRM, which, in addition to technical flood protection, also takes into account spatial planning, risk communication and participatory processes. Instead of striving for 100% flood protection, planning and decision-making processes must increasingly take residual risks into account (Bubeck et al., 2015; Fuchs et al., 2015). Responsibility should be increasingly taken by the affected society (Mees et al., 2016), and therefore more equally divided between the authorities and society, to prepare for future flood events. Among other relevant variables, several studies have shown that risk communication, which is tailored to the needs of affected residents, can influence their perception of risk (Bubeck et al., 2012;

Botzen et al., 2013; Attems et al., 2020). This can consequently also influence their behavior to implement PLFRA measures on their properties (Hear et al., 2016; Van Valkengoed & Steg, 2019). The study sought to answer the following overarching research question: How can risk communication be applied to enhance individual adaptation in flood prone areas and thereby improve responsibility sharing processes in FRM?

Participatory methods employed

As it is vital to integrate all stakeholders (homeowners, experts, authorities) in FRM, so that opinions become well understood. To improve risk communication processes, different methods for engagement were applied.

Homeowners: To actively engage homeowners in research on FRM, PLFRA measures and risk communication, a bootstrapped Q-methodology was applied. This exploratory technique (Watts & Stenner, 2005) provides room for flexibility and creativity to integrate the research subject in an interactive way (Eden et al., 2005; Zabala & Pascual, 2016). Originally introduced by Stephenson (1935), Q-methodology has since been applied in several different fields of research, including environmental sciences (e.g., Venables et al., 2009; Lynch et al., 2014; Živojinović & Wolfslehner, 2015; Hermelingmeier & Nicholas, 2017; Langston et al., 2019; Tuokuu et al., 2019), and FRM (Raadgever et al., 2008; Bracken et al., 2016; Snel et al., 2019; Attems et al., 2020b). Compared to interviewing, Q-methodology can be reproduced to group different perspectives and it combines qualitative and quantitative data. It hence solves several qualitative research dilemmas, as it gives a certain structure to the process of analyzing qualitative data (Wright, 2013). The method does not measure the spread of views in a population, but rather shared viewpoints (Eden et al., 2005).

Applying this methodology, the perspectives of 20 residents in Austria's second largest city, Graz, and surroundings were explored. All participants have experienced flood events on their properties. 51 statement cards on topics related to FRM (e.g., risk communication, individual adaptation, risk behavior, etc.) were prepared and handed out. The respondents were asked to read the statements and sort the cards in a grid based on a Likert scale from -5 (most disagree), 0 (neutral) to +5 (most agree). While placing the cards, they were asked to explain their decisions, which were recorded and transcribed. The acquired quantitative data was analyzed using R statistics. A bootstrap was applied based on Zabala and Pascual (2016).

Experts: To understand the process of tailor-made advice given by experts, a focus group was applied to engage different experts in a discussion. The aim of conducting a focus group is to gain insight into views and experiences as well as the experts' ways of thinking. A focus group is usually conducted in an informal setting, where topics can be discussed with 6-10 participants. This allows for an open discussion, rather than answering "yes" or "no" questions, and compared to interviews, interaction between the participants is enabled. Hereby more information can be gathered on a topic, while saving time (Flick, 2009; Clifford et al. 2010). Four properties at risk of floods along theElbe in Dresden (Germany) were explored. All four objects have been affected by floods in the past (2002 and 2013 were the most significant events). The objects were selected in advance by an expert, who regularly gives advice on objects regarding flood risk and the mitigation thereof in this area. The objects were both private and public buildings (residential buildings with art gallery, residential buildings and interior design, kindergarten, church community). The tailor-made advice, and hence first contact between the expert and the homeowner seeking advice on site, lasted between 90 and 120 minutes. Following the observations of the individual consultation, a focus group was carried out with four experts. All experts have given technical advice on PLFRA measures either in Germany

or in Belgium. The topics discussed included the role of the expert in the consultation process as well as the importance of having the right tool (e.g., excel document with options of measures vs. an interactive map for both the expert and the homeowner) and the flexibility needed as cases vary drastically. The discussions were recorded and transcribed.

Authorities: 22 semi-structured in-depth interviews were undertaken with FRM authorities in Vorarlberg, the most western province of Austria, (from here on referred to as authorities) to assess the current flood risk governance arrangement, and its opportunities and limits regarding responsibility sharing and the implementation of PLFRA measures. Vorarlberg is currently experiencing rapid socio-economic development (Statistics Austria, 2013), reflected in substantial increases in the gross regional product (Statistics Austria, 2019). Additionally, as flood risks might be intensified in the face of climate change (Kundzewicz et al., 2005), especially in mountain regions (Zimmermann & Keiler, 2015), a shift in responsibilities to decrease vulnerability to floods is inevitable.

The interview partners depict a broad range of representatives with expertise in flood risk management, spanning from municipal land-use planning, emergency management, water engineering and FRM to geology to the insurance sector and academia (Rauter et al., 2020) at all three governance levels: 1) Local/decentralized: City of Dornbirn (n = 7), 2) Regional: Province of Vorarlberg (n = 11), and 3) National/centralized: Republic of Austria (n = 4). Regarding data analysis, the interviews were transcribed and analyzed using the qualitative data analysis software f4 (Dresing et al., 2012).

Insights and major lessons learned

With potentially increasing flood risks due to climate change and increased vulnerability following high socio-economic development in flood prone areas, combined management approaches are inevitable to tackle such challenges. The results of the stakeholder engagement activities showed, quite homogeneously, that participatory communication methods are needed to enhance individual adaptation.

Homeowners: Results showed that different opinion groups have to be considered in risk communication practices, as the knowledge and extent of individual adaptation varies greatly.

Homeowners

• Q-methodology was an effective approach to integrate the research subjects in an interactive way.
  ○ Compared to interviewing, the respondents had to think of the topics in a different way and the statements triggered different emotions and opinions.
  ○ However, it is quite time consuming, implying a limited number of participants.
• Generally, the method showed different opinion groups which indeed varied greatly regarding e.g. the risk perception, risk behaviour and the preferred mode of communication and participation concerning public and private flood protection measures
• Thus, the method was effective in showing that a majority of residents affected by floods can only be reached, by implementing diverse risk communication modes (participatory approaches, community meetings, brochures, etc.).

Experts: Affected residents who actively contact the experts usually have already implemented PLFRA measures or have a very clear understanding of which measures they want to implement. The process of technical advice is not exclusively based on the knowledge of the experts, but also on mutual knowledge transfer between experts and affected residents. The experts must react very flexibly (e.g., regarding the building structure, the extent of the

flood risk, the type of flood risk, the expectations of those affected) in order to develop effective solutions. The opinions and experiences of the experts were very homogeneous. The results of the focus group showed that the experts consider themselves responsible for strengthening adaptive behavior among the affected population. Experts should therefore build on these experiences and ideas of the residents.

Experts
• The focus group applied with the experts was effective in gathering this group of people for in-depth discussions. • The creation of a "one-size-fits-all" solution is therefore unrealistic. • Although the experts give various recommendations to the affected residents regarding PLFRA measures, the decision is lastly made by the affected residents. • It is considered difficult to verify whether PLFRA measures were implemented after consultation, as there is not always a "follow- up" process in the handling of expert advice. Thus, it remains uncertain whether residents implement measures, and whether implemented measures are effective. • However, we saw that few individuals usually lead the conversation while others withhold. Without proper moderation an unbalanced perspective might result.

Authorities: Even though acquiring a group of representatives was relatively straightforward in this case, the count of interviews remains relatively small.

Authorities
• While qualitative research, compared to quantitative research, allows for a more detailed assessment of the research interest, the method also leaves room for interpretation. • This refers to both the researchers' risk of bias but also to how questions are answered by the interviewees. • Furthermore, as is expected with open-ended interviewing, answers to specific questions ranged quite substantially. • Probing questions finally led to more precise answers and therefore comparable data, however, also led to extended interviews, taking between 30 minutes and over an hour.

Co-designing future water pathways for the Indus Basin

Problem setting and objectives

The Indus basin is one of Asia's longest rivers, with headwaters in Afghanistan, China and India, and flowing through the length of Pakistan. The basin is home to about 250 million people of which 61% live in Pakistan, 35% in India, 4% in Afghanistan and less than 1% in China (Vinca et al., 2020). Most basin inhabitants live on low incomes, with half of the population working in agriculture. Approximately 110 million people live in extreme poverty (<US$ 2 per day) (ibid). With low to moderate levels of access to basic services, healthcare, and education, large parts of the population are vulnerable to climate impacts and have low adaptive capacity. These socio-economic challenges coupled with rapid population growth (expected to increase up to 70% by 2050) will subject the basins' water resources to an increasing stress.

The opportunities to overcome many of these development challenges and to pave the road to a sustainable future are numerous, but strategic decisions would need to be made across the different sectors and countries to manage potential trade-offs and maximize the effectiveness and the co-benefits of the proposed investments. Yet, sectoral and countries' development plans are being conceived in isolation. There is a need to assess how the plans will unfold together and anticipate potential impacts to plan accordingly. This is particularly important given the uncertainties linked to increasing climate variability and change and the

socioeconomic perspectives that foresee a substantial increase in the demand for natural resources, which could eventually trigger political tensions across borders.

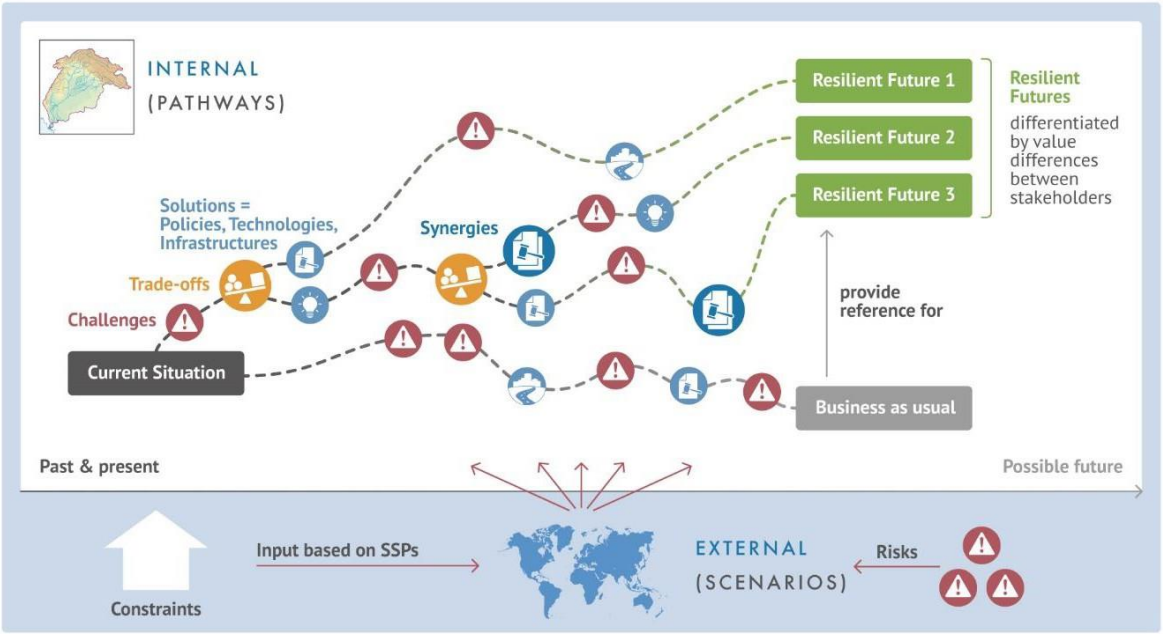
The “Integrated Solutions for Water, Energy and Land project (ISWEL) has focused its efforts in supporting the development of tools and capacities within the Indus basin to address the interlinkage between water, food and energy plans across sectors and countries, and in the light of the global changes ahead such as population rowth and climate change. The main objectives of the project were: 1) Identifying country and basin challenges, priorities, and trade-offs in the management of the water- energy-land nexus, from the diversity of stakeholders´ perspectives; 2) Supporting the co-development of sustainable visions for the Indus basin and associated transformation pathways; and 3) Enhancing a shared understanding on the implications of different investments in the basin, cascading through the water-land- energy sectors. We emphasized the exploration of different perspectives, values, and worldviews to allow different stakeholders’ groups (sectors, countries) to articulate coherent future goals and their strategies to reach these goals. For example, some stakeholders aspire to the vision where agriculture continues to be a primary source of income in the Indus basin while others see urban-based economy as a source of future wealth. When it comes to transformation pathways, water shortage or excess being a primary source of risk, can be addressed either through big infrastructure investments, or nature-based solutions.

Participatory approaches implemented

Collaborative Sustainability Pathways Development: High stakes and deep uncertainties regarding the future make the case for the use of scenario approaches. Scenario exploration prepares us for a wide range of future possibilities while taking into account existing development plans, visions and strategies. Despite its potential, both research and practice of scenario building attest that there remains a significant challenge in addressing the specific needs of diverse user groups (Parsons 2008), as well as in representing and integrating the multiple drivers operating at different scales that can shape the development of the basin (Wada et al., 2019).

To address the interconnected risks and development challenges in the Indus basin, the scenario approach that was implemented in ISWEL adopts a participatory, multi-scale approach (Wada et al., 2019). The premise is that drivers operating and influencing the development trajectories in a given region occur at different scales (from local to global), and therefore it is important to differentiate the so-called “sphere of influence”, which embraces all the measures and policies that basin stakeholders (regional to sub-national) have the ability to agree and adopt, and that will determine the pathways to achieving the desired water, energy and land targets. However, the resulting pathways are of course not immune to important global developments and potential for external shocks. Hence, the approach also distinguishes the so-called “sphere of uncertainty”, which embraces global drivers such as climate change scenarios and global socioeconomic trends, against which regional pathways need to be adapted to become robust. Figure 2 depicts the 4-step scenario process implemented to co-define the stakeholder pathways for the Indus basin.

Figure 4. Conceptual representation of the co-development of the nexus visions and transition pathways. in the Indus Basin Source: Wada et al. (2019). Note: For this exercise we used as external scenarios those developed by the Intergovernmental Panel for Climate Change (IPCC) and specifically the Shared-socioeconomic Pathways (SSPs) and the Representative Concentration Pathways (RCPs). See O'Neill et al., (2013, 2017) for details.



STEP 1: Build a common understanding of the current situation and the main sectoral and countries´ challenges. The process starts with characterizing the current situation of a basin, represented in a simplified visual format. To this end, a predefined set of materials such as maps and cards with descriptions of infrastructure, economic activities and resources were provided to facilitate discussions. Such visual representation provided an opportunity for better understanding and a deeper discussion of key issues among stakeholders within and across sectors and countries. Stakeholders involved included: provincial and national decision makers, donors, academia, and practitioners, from all four riparian countries, although with a larger representation from India and Pakistan.

STEP 2: Developing future pathways: "business as usual". Based on this joint assessment of the current situation (developed in the previous step), participants developed "business-as-usual" (BAU) pathways – i.e., a series of changes (new investments or initiatives) of the existing situation that is likely to happen if current water, food and energy policies and development plans continue. These changes were represented visually by adding or changing existing elements on the map, such as development of new dams, expansion and upgrading of irrigated area and infrastructure, improved access to water and sanitation, to name a few. Additionally, the proposed investments and initiatives were also represented separately along a timeline depicting the pathway from "now" to the future.

STEP 3: Developing the basins' visions and pathways to desired futures. Three visions of "desired futures" were developed together with their corresponding pathways. Unlike the BAU that continues existing policies and directions, the desired futures started from clear, ambitious but realistic visions of what can be achieved. Stakeholders from the 4 riparian countries and sectors were arranged into three different groups, representing three basin development priorities: economy, society, and environment, respectively. The focus on priorities was not supposed to eliminate other important concerns - all the visions were aimed to be holistic. The

rationale for such an approach is that stakeholders have a wide range of preferences, values, and worldviews which make it difficult for everyone to agree on one single desired future. Typically, these divergent values and preferences manifest in difficult trade-offs that need to be weighted (see Figure 2). Such trade-offs create critical branching points, where a choice of a particular option results in alternative pathways. For example, developing large scale water infrastructure vs. small scale nature-based solutions may lead to alternative pathways.

STEP 4: Improving the robustness of pathways – addressing challenges from global scenarios. To test robustness of the chosen solutions under unfavorable external circumstances it is also beneficial to consider some undesired global scenarios. The differences between alternative global scenarios are represented with a set of externally imposed challenges along the analyzed regional pathways. For the purpose of this exercise, it is proposed to work with the IPCC Shared Socioeconomic Pathways (O'Neill et al., 2013, 2017) to provide a global context and delimit the sphere of uncertainty, as well as with the Representative Concentration Pathways (RCPs).

Insights and lessons learned

We learned that a carefully designed process can be used even in conflict situations. Political tensions across the border are high in this part of the world. This posed an enormous challenge from the design perspective of the participatory process to create a comfortable environment for stakeholders to open up and engage in co- creation exercises. As opposed to other regions where the same scenario workshop was applied, for the Indus we had to adapt the implementation plan following the feedback received from many stakeholders. Prior to the scenario workshop, the team decided to hold a number of separate national consultations following the requests of some stakeholders, with the intention of gaining a better understanding of the stakeholders' views from a country perspective. This process also allowed the project team to get substantial insights into the specific challenges and demands within countries, and importantly, build bridges and mutual trust between country partners and the project team. These country consultations were hold in India and Pakistan and provided the necessary trust to later engage stakeholders from across the four riparian countries into the joint scenario workshop. During these meetings, we further adopted several decisions to ensure participants and conversations stayed open, which is crucial for a highly creative and engaging process: (1) to make clear to all participants that the project team and the process designed was science based and thus intended to use evidence base as a vehicle for discussing and exchanging views about development challenges, which ultimately matter to all riparian countries; (2) to enable a free and open environment, by proposing to adopt the Chatham House Rule.[3]

The game-like display of the scenario policy tool also made the exercise more appealing to stakeholders given that it was an easy-to-understand way of developing a joint vision about existing challenges and possible pathways ahead. To keep the representation "playable" (not involving too many elements and steps) we had to dramatically simplify the representation, however, as the stakeholder session revealed, even a crude quantitative representation of the system, when done interactively offers several advantages over a detailed but passive presentation. We found that more experiential approaches for stakeholder workshops, such

[3] When a meeting, or part thereof, is held under the Chatham House Rule, participants are free to use the information received, but neither the identity nor the affiliation of the speaker(s), nor that of any other participant, may be revealed.

as the Nexus Game (Mochizuki et al., 2021), result in much higher engagement and better-quality outputs.

Identifying and communicating systemic dimensions of flood risk and disaster risk management in Peru

Problem Setting and Objectives

Peru's Pacific slope is an arid region periodically impacted by extreme flooding linked to the El Niño phenomenon (the warm phase of the El Niño-Southern Oscillation), as well as the similar but more localized and infrequent "coastal El Niño" events (Rodríguez-Morata et al. 2018). During each of the strong global El Niños of 1982-83 and 1997-98 and the coastal El Niño of 2017, Peru experienced billions of US dollars in infrastructural damages and hundreds of injuries and deaths (French and Mechler, 2017); and the frequency of extreme El Niño events in this region may only increase under a warming climate (Wang et al. 2017). In response to El Niño and other natural hazard related catastrophes, disaster risk management (DRM) activities have received increased political attention and funding allocations in recent years, and institutional innovations in Peru's DRM sector are well aligned with the recommendations of the Sendai Framework and its predecessors (UN, 2014). Nevertheless, the effective implementation of DRM measures continues to be undermined by the country's prevailing development patterns, including rapid and insufficiently planned urbanization and infrastructure creation in high-risk settings, and by governance challenges such as widespread corruption and ineffective coordination across levels and sectors of both government and society (UN, 2014; French et al., 2020). Further complicating DRM is the substantial uncertainty linked to El Niño event onset and severity (characteristics shared with seismic hazards), and related issues of risk communication and preparedness (Glantz, 2015; French et al. 2020). Given these challenges, there is an urgent need to improve understanding of how disaster risk is influenced by the dynamics of a wide range of distinct but interacting environmental phenomena and conditions and social structures, perceptions, and practices.

In this research, we worked to conceptualize and examine these diverse dynamics in the context of the socio-environmental systems which they shape and in which they are simultaneously embedded, thereby highlighting how factors such as geophysical hazards, development policies and practices, demographic trends, and differential access to various "capitals" (e.g., physical assets and social relationships) interact to produce disaster risks in specific ways for particular groups. Specifically, through activities associated with the Zurich Flood Resilience Alliance Project, we set out to analyze these "systemic" dimensions of flood risk and DRM implementation, with a geographic focus in the region around the national capital of Lima. A key objective of this process was to work closely with a local NGO partner with extensive knowledge of local processes and with existing relationships in government and civil society to co- develop strategies for exploring and communicating interacting dynamics of disaster risk with a range of stakeholders, including policy makers and local residents.

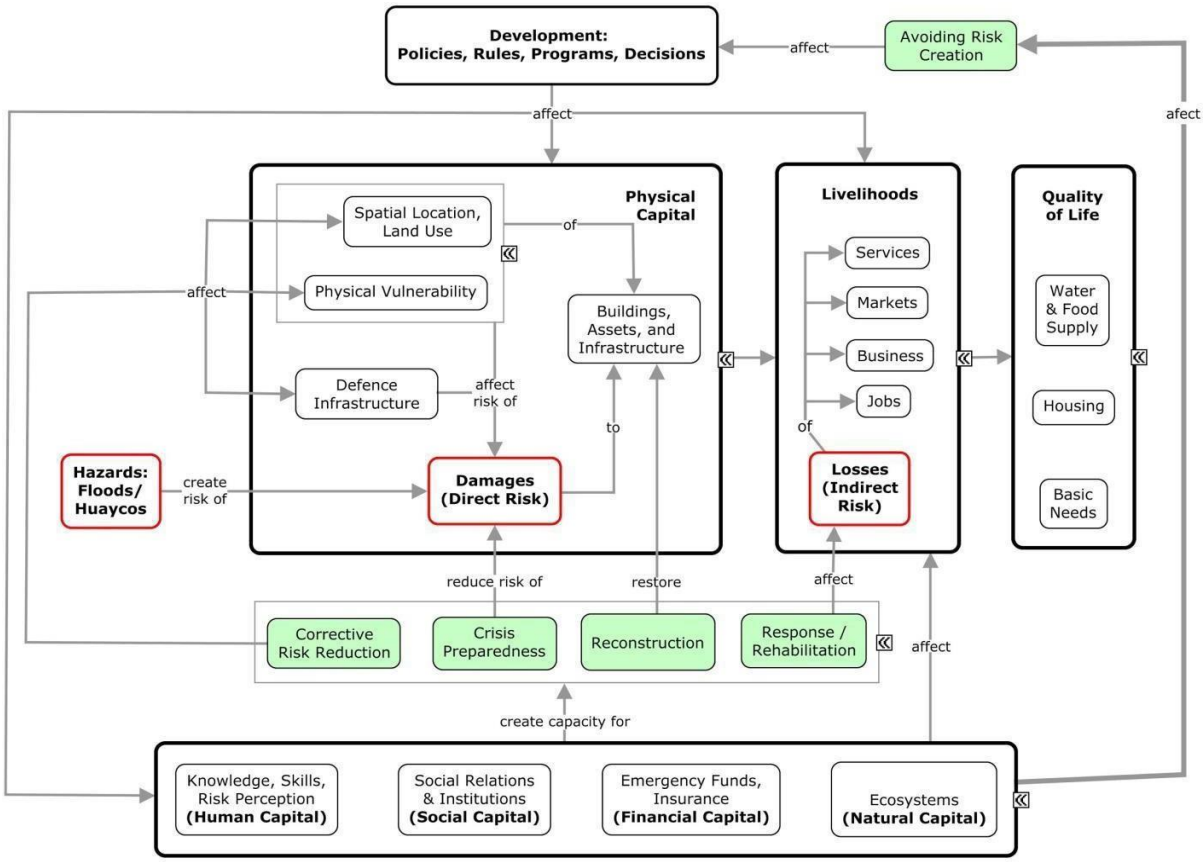
Participatory methods employed

Introducing a conceptual framework for disaster resilience: Initial engagement with Peruvian partners, DRM personnel, and community members was centered around developing and refining a conceptual framework to illustrate the interactions and interdependencies between livelihood production and development processes, hazards and disaster risk, and DRM practices with the ultimate goal of supporting system-based conceptualizations and understandings that could contribute to planning and policy for long

term resilience (Keating et al. 2017). As a point of departure, a simplified draft “system” framework was developed by our researchers to be presented to various stakeholders from flood-affected communities (local residents, local and regional level policy makers, and DRM-sector personnel) in a workshop setting.

The intent of this approach was both to refine the framework through community input to make it relevant to the local context and to use the process of refinement and the resulting systemic depiction to elicit conversation about the interacting dynamics contributing to vulnerability and resilience in the region of focus (see Figure 5 for the final FLORES framework after several co-design iterations with stakeholders). This approach worked to a degree, as the framework served to stimulate an engaged discussion that highlighted several important social and political factors associated with disaster risk, including some that were obvious to community participants but often excluded from policy-level discussions and “expert”-led dialogues (for example, the role of corruption in enabling, and even encouraging, risk-prone settlement and development). In general, workshop participants and DRM practitioners felt that the final FLORES framework was effective at mapping what they knew intuitively, thereby affirming their views of basic system components and dynamics and providing a useful graphic illustration of these elements. Additionally, the workshop dynamics - in large part through the critical stance of its facilitator - served to foment an unexpected but important group discussion that presented various critiques of expert-led knowledge production and dissemination versus the co-production of knowledge through community participation. This dialogue was important in making critical perspectives within participating communities explicit and underscored the importance of creating realistic and explicit objectives and expectations with all project partners. Over the duration of our multi-year collaboration with the local NGO partner, the FLORES framework provided a shared set of focal concepts and issues for both groups, helping researchers to understand specific local processes as well as the perspectives of different stakeholders, while supporting our partners and workshop participants in conceptualizing the important interconnections and a “big picture”.

Figure 5. Final FLORES framework after several co-design iterations with stakeholders.



Exploring system dynamics and stakeholder positionality through game-based engagement: As researchers separated from our project partners by both significant physical distance and socio-cultural barriers (e.g., limited language and cultural familiarity), we became increasingly aware of challenges and limitations related to the kinds of participatory research approaches and outcomes that we could reasonably pursue and achieve, especially within the relatively short field visits (1-3 weeks) and constrained time horizon of the l project (2 years). Our early engagements bringing together diverse stakeholders also emphasized the complex, and at times contentious, inter-group dynamics that existed within and between communities of residents, policy- makers, and NGO and DRM professionals within Peru. In response to these challenges, we began to explore research strategies that could support the exploration of systemic dimensions of risk creation and mitigation for a range of stakeholders, while avoiding problems linked to our own positionality as foreign “experts” as well as the complicated, and typically tacit, local social dynamics of which we had limited awareness and understanding.

Through prior experience with game-based policy simulations, we recognized the potential in such approaches to create a setting in which stakeholders from different social groups and cultural positions could come together to explore complexproblems from diverse perspectives, thereby gaining an appreciation for the values, constraints, and capacities that influence the behavior and decision-making of specific “roles” or “players” in these contexts. We thus incorporated many of the empirical flood risk dynamics under investigation in the Peruvian context into a stylized game involving role-playing and scenario navigation by participants

representing residents, business owners, resource managers, and policy makers involved in day-to-day life in a common watershed. The game requires players, who have distinct and variable levels of affluence and resource access, to make decisions, both independently and in conjunction with others, related to both short and long-term development and risk management. As the game unfolds, various costs, benefits, and trade-offs related to specific decisions and development pathways become apparent, and as participants experience this learning process they are confronted with additional decisions under conditions of limited information and high levels of uncertainty about future risks. At the conclusion of the play, the overall wellbeing and resilience of individual players and the broader community is assessed by the facilitator, and a guided conversation debriefing the experience and connecting game dynamics to specific outcomes is undertaken.

The prototype version of this Flood Resilience game was played and refined with our research partners in Peru, and they later adapted the game for their own use with local residents in Peru and beyond. In the contexts in which we observed the game, it effectively supported social interaction and learning in relation to system dynamics, and it highlighted the distinct values and objectives held by different stakeholder roles within the design. Moreover, the game illustrated the important potential to use play-based, participatory approaches as a starting point for facilitating discussion and analysis of politically charged and contentious topics.

Insights and lessons learned

Our engagements with Peruvian research partners, DRM practitioners, and community members provided several useful lessons relevant to conducting participatory research on complex problems in cross-cultural contexts. First, due to the larger project's short timeframe and a process in which we initially coordinated with our NGO partner's UK branch, we jumped straight into intensive workshop preparations with our Peruvian counterparts without sufficient prior engagement to cultivate the personal rapport and shared understanding and trust that facilitate the development of commonly held research objectives. As a result, there were differing assumptions and expectations between researchers and local practitioners that generated misunderstandings and undermined our efforts, particularly in the initial stages of our work together. Fortunately, we continued to collaborate in an iterative process that permitted flexibility and the adaptation of our methods, allowing us gradually to cultivate shared goals and understanding. Over the life of the project, we developed and tested multiple approaches and tools (e.g., the FLORES framework and the Flood Resilience Game) to link stakeholders and support understanding of systemic risk dynamics, as well as to communicate these dynamics to different audiences. Our partners would go on to apply these approaches and tools to varying degrees in their work with local communities.

In light of this experience, we stress the importance of including participation principles and relationship building in the project design phase. Projects aimed to understand and reduce disaster risks are often developed by experts/researchers without sufficient consultation or involvement of local stakeholders. While practical issues (e.g., availability of funds, language barriers, lack of relationships) may make stakeholder engagement difficult at the project-design phase, there is a crucial need for substantive involvement and clear and consistent communication and expectations for all parties in participatory research endeavors. Such clarity can be achieved only through extensive interactions and mutual learning between the partners. In short, this research experience underscored that, regardless of how invested partners may be, robust and effective participatory approaches require ample resources and

time to develop strong relationships and shared objectives, especially when engagement is occurring across socio-cultural differences.

Enhancing policy relevance of scientific knowledge in East Africa

Problem setting and objectives

Agricultural is critical for the economy of East Africa accounting for approximately 25 to 40% of the East African Community's GDP and employing more than 80% of its labor force (East African Community 2020). Africa's crop yields are only 56% of the international average (African Development Bank 2017), largely due to an absence of water control measures such as irrigation, lack of mechanization, and high susceptibility to climate variability with frequent floods and droughts (East African Community Secretariat 2016). There are many pilot projects aimed at improving agricultural water management, however, scaling-up of such solutions is constrained by a number of factors such as resource constraints, lack of harmonization and alignment, coordination among stakeholders (Burtscher et al. 2018) and sound understanding of large-scale benefits and trade-offs of the innovations.

Against this backdrop, the project "Scaling out resilient water and agricultural systems (scaleWAYS)" in East Africa, analyzes upscaling options for water and land management practices for the resilient and sustainable intensification of agricultural production and food systems in the extended Lake Victoria Basin. Unlike traditional scientific assessments aimed at generating 'knowledge products' such as scientific and policy studies, the scaleWAYS approach combines biophysical and agro-economic simulations, with political economy analysis and anchoring of scientific knowledge through a Community of Practice, as a way to enhance policy impact and strengthen flood and drought resilience in scaling sustainable rice and fodder production.

Participatory method employed

The different activities of the project are identified and interwoven through what is known as a "Theory of Change (ToC)" commonly used by development projects to achieve the desired impact. Maru et al. (2018) describe ToC as approaches which enable project partners to present and test their theories and assumptions about why and how impact may occur. TOC is also aimed at developing a shared understanding of the processes and underlying mechanisms by which interventions are likely to work (Buck et al. 2018) and achieve the intended outcomes or impact. The ToC uses a backward mapping approach which starts with the intended long-term outcomes of the intervention and moving back pointing out short- and medium-term outcomes required (intermediate outcomes, development outcomes) and identifying (research) activities which lead to outputs necessary to achieve the intermediate outcomes. These elements of the ToC are arranged in a results chain or impact pathway. (Anderson A. 2005; Buck et al. 2018; Abercrombie et al. 2018).

Figure 6. Generic ToC for scaleWAYS.

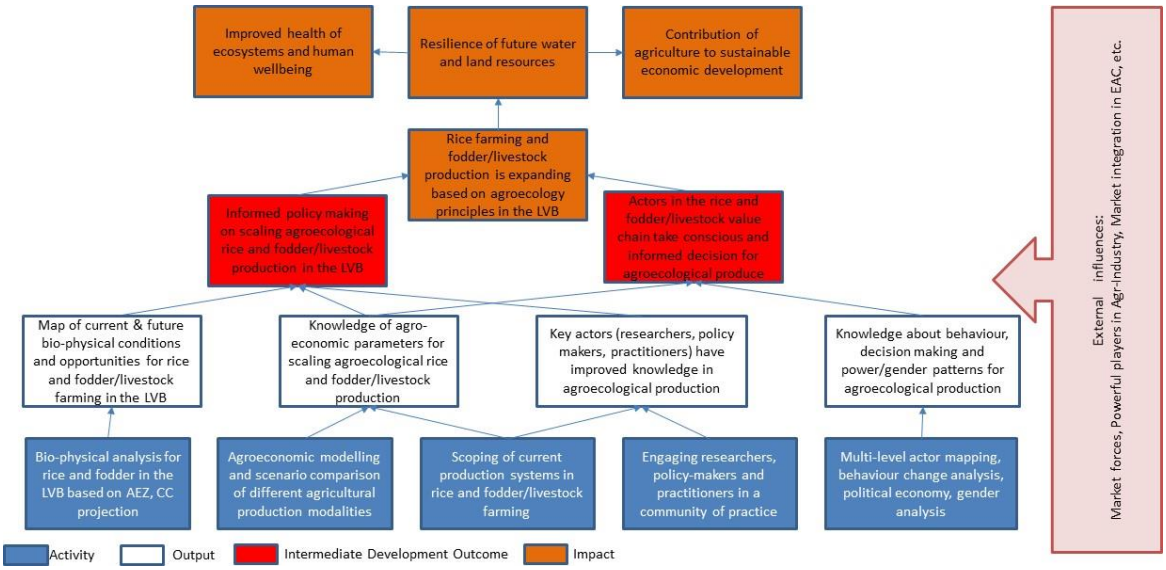
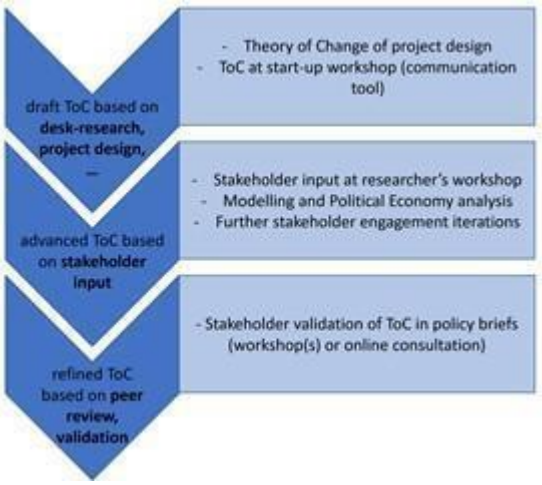


Figure 6 depicts the generic ToC for the scaleWAYS project, which starts with the activity level (bottom) and connects to outputs, intermediate development outcomes and impact including some explanatory causal links and external influences. A ToC helps both scientists and wider policy stakeholders to understand the design of an intervention (in our case a research project) and visualizes how pieces of a particular intervention, such as biophysical model assessment, political economy assessment and community of practice fit together. The ToC may also be used to communicate the analytical outputs – i.e. proposed scaling options or solutions thereby serving as a strong communication tool for translating research findings to policy making. Depending on the complexity of the project, it is helpful to present impact pathways and sub-pathways in a nested approach dealing with intermediaries (Mayne and Johnson 2015, p. 421). One of the nested ToCs in scaleWAYS therefore looks at the political economy analysis, including behavior and decision-making process of actors involved in the scaling out of resilient and sustainable agricultural practices for intensifying rice and fodder production. Researchers and project partners (researchers from local universities, policy makers from ministries, extension service providers etc.) engage in ongoing processes of policy development such as integrating resilience dimensions in an ongoing rice production strategy formulation in East Africa. Our ToC clarified that the goal of the research is to feed evidence (from modelling and political economy analysis) into such processes, and given the dynamic nature of the contexts, to be aware of and responsive to changes as knowledge and learning enhances.

As visualized in Figure 7, the first scaleWAYS ToC was developed in a project planning workshop with technical and management staff of the Lake Victoria Basin Commission and is part of the project proposal which eventually received funding from the Austrian Development Agency. This ToC of the project design stage was used in the project start-up workshop to engage with the stakeholders invited to this workshop and to discuss the project including its planned outputs, development outcomes and intended impact in detail. Key purpose was to create ownership for the project and contribute and engage in project activities, mainly through a Community of Practice.

Figure 7. Theory of Change design process in scaleWAYS project (Buck et al. 2018, modified).



In a second interaction, the ToC was refined in a workshop with broad participation from policy makers and researchers from the target countries of the study. In this workshop, among other aspects, participants looked at the details of the research design and used the ToC to adjust the methodologies and approaches of the project. This ToC was further adapted and refined in an online research seminar which went into understanding the theoretical and methodological background of a ToC approach. In the next steps of the research project, key research results and solution options for resilient and sustainable intensification in rice and fodder production will be discussed with stakeholders and ultimately validated as policy options in a validation workshop.

Insights and lessons learned

In research for development projects, ownership of the research outcomes by actors and stakeholders of the subject of research is vital, if these are expected to achieve impact on policy making and changing practices on the ground. This requires engagement of partners from the onset, however, an effort to combine scientific studies with policy engagement with an ultimate goal to achieve development impact may quickly become a convoluted process, unless chain of impacts are clarified and agreed among project stakeholders. Our insights show that building a ToC and clarifying associated impact pathways turned out to be a very useful approach to steer the intervention (research project) itself, structure the research approach through nested sub-ToC for addressing particular research question, and will be used to communicate research findings for policy makers in a convincing and easy understandable way. For understanding behavior related aspects such as roles, motivations and decision rationales of actors in scaling out of practices such as resilient and sustainable agricultural practices, a ToC approach turned out to be very suitable.

The notion of reach as introduced by (Mayne and Johnson 2015) is important to achieve impact. In this regard, it is helpful to disaggregate a more complicated pathway, namely by developing impact pathways and a ToC for different actor groups (including partners, intermediaries, and beneficiaries) who need to be 'reached' by the intervention. These specially designed ToC charts can be used as the basis for engaging with each actor group in an effective and targeted way.

Synthesis of insights and discussion

Building on the comparative case study assessment framework suggested by Aubert et al. (2019) and on Mintzberg and Westley's (2001) three modes for participatory decision making (thinking, seeing, and doing), Table 1 summarizes the answers to the "what, why, how, who, when and where" questions, as well as opportunities and challenges of the participatory research approaches employed in our five case studies.

Although there is increasing recognition that scientists working on policy-related issues must do more to engage affected stakeholders in their research efforts, both sides often struggle to accomplish and benefit from this engagement. Researchers, for example, may consider inviting public officials, practitioners, and community members to workshops to elicit useful input to their studies or receive feedback on preliminary results as sufficient engagement. Practitioners (either from public authorities or NGOs) and members of the general public, on the other hand, are often entrenched in their institutional contexts or daily lives and may see few incentives for engaging with scientists. Although, as researchers working at the policy interface, we are aware of such challenges. We nevertheless found ourselves confronting these dynamics as we struggled to achieve satisfactory interactions in our case studies.

We have learned that the successful implementation of any participatory research requires solid planning and hinges on the integration of all interests, since any dissatisfaction on the part of participants with the content or form of a participatory process can have an adverse effect on the substantive results of the collaboration. Thus, the following list, building on Prutsch et al. (2014) and extended with insights from the five case studies described in this paper, summarizes important points in preparing, implementing and postprocessing a successful participatory process.

Table 1. Defining the "what, why, how, who, when and where" and synthesizing the main opportunities and challenges of our participatory research approaches.

Case name	RESPECT	FLOODLABEL / SHARED	ISWEL	FloodResilience	scaleWAYS
What? (Hazard addressed)	Flood and drought risk	Flood risk	Climate change impacts on water, food, & energy demand/availability	Flood and landslide risk	Climate Change impacts on agricultural production
Where? (Location)	Europe (Austria)	Europe (Germany, Austria)	Asia (Indus River Basin)	South America (Peru)	East Africa (Lake Victoria Basin)
Why? (Problem context/ issues being addressed)	Roles and responsibilities are often unclear in CRM and perceived differently by different stakeholders, potentially leading to misunderstandings and conflicts in practice.	Roles and responsibilities for private adaptation are distributed unevenly and new ways need to be found to rearrange tasks so that future flood risks and impacts are tackled effectively.	Integrating water, energy, and land issues in the transboundary river basin; exploring sustainability pathways to desired futures in the context of global scenarios.	Understanding system dynamics related to flood risk and resilience: linkages and interdependencies between development, disaster risk, DRM, and resilience.	Policy reforms to address low agricultural productivity and resilience to climate change are poorly informed by scientific knowledge and novel concepts like agroecology.
How? (Participatory approaches taken to address the issues above)	Developing and testing of a role-play simulation to disentangle the complex roles and responsibilities in CRM	Different stakeholder engagement methods were applied (Q-methodology, focus groups, expert interviews) to shed light on roles and responsibilities of stakeholders in PLFRA implementation.	Collaborative and interactive pathway development (also called policy simulation approach).	Developing and testing conceptual frameworks and game-based approaches to understanding and communicating system dynamics.	A Theory of Change (ToC) approach was developed to clarify intended development outcomes of the project right from the onset and is used to engage with stakeholders throughout project implementation.
How? Modes of engagement	• Thinking • Seeing • Doing	• Thinking • Seeing	• Thinking • Seeing • Doing	• Thinking • Seeing • Doing	• Thinking • Seeing
Who? (Actors participating in approach)	Local level stakeholders in DRR in Austria (mayors, DRR practitioners, farmers, private households)	Various stakeholders in PLFRA (homeowners, experts and practitioners, authorities)	Representatives of all four riparian countries (researchers and practitioners)	• Policy makers, DRM personnel, local residents and community members	Researchers from local universities, policy makers from ministries, extension service providers

Who? (Actors participating in approach)	Local level stakeholders in DRR in Austria (mayors, DRR practitioners, farmers, private households)	Various stakeholders in PLFRA (homeowners, experts and practitioners, authorities)	Representatives of all four riparian countries (researchers and practitioners)	Policy makers, DRM personnel, local residents and community members	Researchers from local universities, policy makers from ministries, extension service providers
Opportunities	• Role-play simulations allow participants to jointly reflect on CRM policy and practice, and to co-create risk management portfolios in a 'penalty free' setting. The method also allows for increasing the understanding of other stakeholders points of view.	• Q-methodology allows for generating insights which exceed the limits of common research approaches like qualitative interviewing and can be used complimentary to those to add more depth. • Conducting a focus group allowed for an open discussion among the group of experts who offered detailed insights in their experiences.	• The visual and interactive character of the approach resulted in a very high level of engagement as well as clarity about the results (sustainability pathways). • Co-production of knowledge with both scientists and stakeholders learning from each other.	• Different modes of engagement (including visual and interactive tools) suited to different stakeholder needs. • Building capacity for using stakeholder engagement tools by local organizations.	• ToC helps to analyze behavioral dimensions of a scaling process, co-design solution options, engage local researchers and practitioners, and communicate and debate scientific knowledge with policy makers. • ToC is useful to visualize how different pieces of a large project work together to achieve intended outcomes and impact.
Challenges	• Very resource intensive development and trust-building phase. • Skilled host is needed for successful implementation. • Success depends on availability and openness of 'the right' stakeholders.	• Finding adequate interview and focus group partners can be challenging and bias might influence results when the interviewer is inexperienced. • Data acquisition and data analysis (through transcribing) can be very time consuming.	• Resource intensive process. • The need to adapt (sometimes add new modules) the quantitative models based on stakeholder input. • Very challenging to implement.	• Limited time to build relationships (trust) with local organizations. • Project bringing opportunities to local stakeholders based on earlier defined agenda rather thanon local demand.	• ToC requires substantial time and resources for proper engagement with relevant groups and actors.

Preparation phase

- The objectives of the participatory engagement, identified against the backdrop of the key contextual conditions, determine who will be involved and to which extent.
- All interests that are to be integrated and considered in a certain decision context should be represented by stakeholders.
- The key participatory process features (e.g., open dialogue and deliberation, power delegation; participation of citizens vs. organized stakeholders) have to be defined.
- The method for stakeholder engagement (e.g., workshop, focus group, role play, serious game) should be selected based on the objectives of the participatory process and tailored to the number of participants. Methods can also be combined.
- Existing participatory methods can only serve as a starting point for a similar casespecific stakeholder engagement process and have to be adjusted according to the respective local needs as well as environmental, socioeconomic and governance framework conditions.
- The resources available for the participatory process (time, money, experienced personnel) must be determined in advance.
- The time resources required from participating stakeholders have to be considered, and the integration process has to be explained in detail from the very beginning (number of events, schedule, expected results, etc.).
- Guard against high expectations on the part of the stakeholders by communicating their power from the start: Will the stakeholders only be informed about the process, will they be consulted, or will they have a say in decisions?
- The roles of stakeholders in the participatory process must be clear. Of course, roles may change over the course of the process; for example, certain stakeholders may be information providers at the beginning, but active supporters in the later implementation of the project.
- The roles of scientists, experts, and the process leaders must also be clearly communicated.
- From the start, explain what will happen with the results of the process.

Implementation phase

- Establish and communicate rules for the participatory process (e.g., neutral moderation, equal rights for all participants, everyone should have a say, all contributions will be considered equally seriously, confidentiality, etc.).
- Continuity in terms of participants should be ensured (especially in working groups).
- The participatory process has to be transparent; all participants should receive the same documents and information.
- Scientific knowledge available at the global scale (e.g., GAR reports) should be linked to the local level and provided in the form of an understandable ‘translation’ to the participating stakeholders. For scenarios to be credible and plausible to stakeholders there is a need to better unfold the underpinning assumptions of the global scenarios,

refine and contrast those with regards to the local context, and expand them based on the local/regional development priorities and plans.

- Cultural factors and beliefs influence the views stakeholders have about the problems at stake and its potential solutions.

Postprocessing phase

- Document all steps in the project (e.g., protocols, interim reports, and photos).
- Participation deserves appreciation: Thank each participating stakeholder.
- Inform participating stakeholders about the outcomes and insights of the participatory process they engaged in and give them an opportunity to provide feedback on the process itself. This can be very valuable for further developing the participatory methods for future applications.

We recommend for the successful implementation of science-policy-practice engagement processes within the UNDRR-SEM to build on our lessons learned and to develop guidance and methodological notes, webinars and e-learning materials for SEM members.

During our participatory research projects presented in this paper, we became increasingly aware of challenges and limitations related to the kinds of participatory research approaches and outcomes that we could reasonably pursue and achieve, especially within the relatively short time-horizons of typical project-funding cycles. As transdisciplinary research is becoming increasingly important for supporting effective and inclusive CRM in practice, we regard it is essential to better align research project funding cycles with the increasing demands on research projects. In particular, if a quality and impact assessment (see e.g., UNDP-UNDESA, 2021) of participatory processes should become a requirement for transdisciplinary research projects – which we believe it should – substantially longer project time-horizons and/ or fast track follow-up funding streams are required.

Conclusions

In this study we synthesize insights, lessons learned, and opportunities and challenges in the development and implementation of stakeholder-focused, transdisciplinary research approaches in the context of managing and communicating climate-related risks that will be of relevance to the global policy audience of GAR 2022. We focus on how collaborative research approaches (1) enable diverse societal stakeholders (scientists, policy makers, decision makers, civil society, private sector, households) to better understand the interacting dimensions of systemic risks as well as each other's interests and needs in addressing such risks; and (2) engage societal stakeholders beyond traditional policy and decision-making communities in informed and inclusive public discussion and debate around challenges and solutions to risk management. Building on six case studies across four continents, we suggest a list of recommendations for the preparation, implementation and postprocessing of a successful participatory process and draw the following conclusions:

- New, innovative methods of stakeholder engagement such as policy exercises, social simulations, and serious games can support the breaking down of cultural, political, and institutional barriers to collaboration, enabling more inclusive, reflexive, and transformative stakeholder processes.
- Transdisciplinary research methods, such as role-play simulations, can support the

identification and allocation of often unclear roles and responsibilities at the complex interface between DRR and CCA.

- Social learning, including cognitive, relational, and normative aspects, embracing all relevant stakeholders, is critical for inclusive and effective risk governance.
- Raising self-efficacy of residents at risk requires tailored risk communication addressing different rationalities and opinion groups.
- The successful implementation of any participatory research requires solid planning and hinges on the integration of all relevant stakeholders' interests.

Our insights and lessons learned from the case studies across four continents are of high relevance for the UNDRR-SEM in fulfilling its key functions: strengthening citizen led and social accountability mechanisms; and promoting coordination, information exchange and harmonization between stakeholder groups. Eventually, building an inclusive and broad bottom-up movement will be crucial for the successful implementation of the Sendai Framework for Disaster Risk Reduction 2015-2030.

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