Chapter 17
Supporting Climate Risk Management at Scale. Insights from the Zurich Flood Resilience Alliance Partnership Model Applied in Peru & Nepal

Reinhard Mechler, Colin McQuistan, Ian McCallum, Wei Liu, Adriana Keating, Piotr Magnuszewski, Thomas Schinko, Finn Laurien and Stefan Hochrainer-Stigler

Abstract There has been increasing interest in the potential of effective science-society partnership models for identifying and implementing options that manage critical disaster risks "on the ground." This particularly holds true for debate around Loss and Damage. Few documented precedents and little documented experience exists, however, for such models of engagement. *How to organise such partnerships? What are learnings from existing activities and how can these be upscaled?* We report on one such partnership, the Zurich Flood Resilience Alliance, a multi-actor partnership launched in 2013 to enhance communities' resilience to flooding at local to global scales. The program brings together the skills and expertise of NGOs, the private sector and research institutions in order to induce transformational change for managing flood risks. Working in a number of countries facing different challenges and opportunities the program uses a participatory and iterative approach to develop sustainable portfolios of interventions that tackle both flood risk and development objectives in synergy. We focus our examination on two cases of Alliance engagement, where livelihoods are particularly being eroded by flood risk, including actual and potential contributions by climate change: (i) in the Karnali river basin in West Nepal, communities are facing rapid on-set flash floods during the monsoon season; (ii) in the Rimac basin in Central Peru communities are exposed to riverine flooding

R. Mechler (✉) · I. McCallum · W. Liu · A. Keating · P. Magnuszewski · T. Schinko
F. Laurien · S. Hochrainer-Stigler
International Institute for Applied Systems Analysis (IIASA), Laxenburg, Austria
e-mail: mechler@iiasa.ac.at

C. McQuistan
Practical Action, Rugby, UK

P. Magnuszewski
Centre for Systems Solutions, Wrocław, Poland

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amplified by El Niño episodes. We show how different tools and methods can be co-generated and used at different learning stages and across temporal and agency scales by researchers and practitioners. Seamless integration is neither possible, nor desirable, and in many instances, an adaptive management approach through, what we call, a *Shared Resilience Learning Dialogue*, can provide the boundary process that connects the different analytical elements developed and particularly links those up with community-led processes. Our critical examination of the experience from the Alliance leads into suggestions for identifying novel funding and support models involving NGOs, researchers and the private sector working side by side with public sector institutions to deliver community level support for managing risks that may go "beyond adaptation."

Keywords Flood risk · Resilience · Science-society partnerships · Boundary objects · Adaptive management · Learning

17.1 Introduction: The 2015 Policy Imperatives and the Implications for the Loss and Damage Debate

International policy as well as local risk and resilience practice are increasingly challenging the scientific community to provide actionable knowledge for identifying acceptable and efficient responses through risk analysis, policy insight and governance studies that help to build resilience. It has been well understood that implementation needs to be multi-scalar involving partnerships between civil society, private sector and government entities (ENHANCE 2016).

17.1.1 Global Policy Imperative-Reducing Risks and Building Resilience

Policy related to climate risk and resilience in recent years has made great strides forward. The *World Conference on Disaster Risk Reduction*, which led to the *Sendai Framework for Action*, demonstrated increasing recognition that a broad-based approach is necessary to incentivise risk reduction, avoid risk creation and generate additional co-benefits that go beyond the direct and indirect gains from reducing risk (UN 2015). The *Sustainable Development Goals* (SDG), passed as well in 2015, constitute a universal set of 17 goals and 169 targets defining development aspiration and ideally transformation in an integrated fashion (UN 2105). A need for transformation is being seen as increasingly relevant for the climate discourse, and at the end of 2015, Paris saw the full endorsement under article 8 of the *Warsaw Loss and Damage Mechanism* (WIM), created at COP19 to "deal with climate-related effects, including residual impacts after adaptation" (UNFCCC 2015).

Demand for broad-based risk and resilience science insight is thus strong with the post 2015 agenda in full swing: the *Sendai Framework for Action* is seeing further implementation at various levels, SDGs are being assessed, mainstreamed and linked to developmental programming and project implementation; the Paris ambition will need to be operationalised in terms of transforming energy and mobility systems towards complete decarbonisation by 2050, as well as strongly supporting climate adaptation (CCA). However, there is robust evidence to suggest that current action and ambition is insufficient to keep climate change at "non-dangerous" levels. Compared to the ambition voiced in the Paris agreement to limit anthropogenically-induced warming to below 2 °C, respectively 1.5 °C, current climate mitigation ambition is projected to lead to significantly greater warming, 3 °C if national pledges are implemented, 4 °C if business as usual is continued, adding to climate-related impacts already experienced across the globe (Climateactiontracker 2018). As discussed in other chapters in this volume (see chapters by Handmer and Nalau 2018; Heslin 2018; Landauer and Juhola 2018) high-level warming would mean pushing some social systems and ecosystems over their adaptation thresholds. As a consequence, there is demand for global evidence to support ramping up efforts for dealing with risks beyond adaptation. This perspective has strong overlaps with the attribution question as laid out in the introduction (chapter by Mechler et al. 2018).

17.1.2 Local Practitioner's Imperative—Learning to Live and Thrive with Floods While Reducing Risk

Calls for assessing and managing risks "beyond adaptation" are being echoed by a practice perspective dealing with severe risks linked to current climate variability already. A key challenge identified and to be addressed by development practitioners working on risk and resilience issues is the nagging feeling that a disaster could wash away generations of hard work by a community in seconds. The limitation for the humanitarian sector is a focus on urgent needs and getting the community back on track, without having the luxury of remaining with the community as they start to rebuild their lives. Thus, the transition from Disaster Risk Preparedness/Management into Community Development, that is ideally sustainable and long-term, is widely recognised as a critical challenge in international development. At the same time, for communities around the world wellbeing is dependent on the ability not only to respond to hazards but also to make the right choices about their future development (see Fig. 17.1 for an example on flood risk).

Large-scale disasters, such as—floods, cannot completely be avoided, but there are measures that can be taken to ensure they do not diminish hard-earned economic and development gains. Learning to live, and thrive, with floods means considering flood risk in planning and investment decisions right from inception, as well as taking steps to protect assets already at risk. It also means planning for response and recovery, which protects and even enhances development and growth potential. Contrary

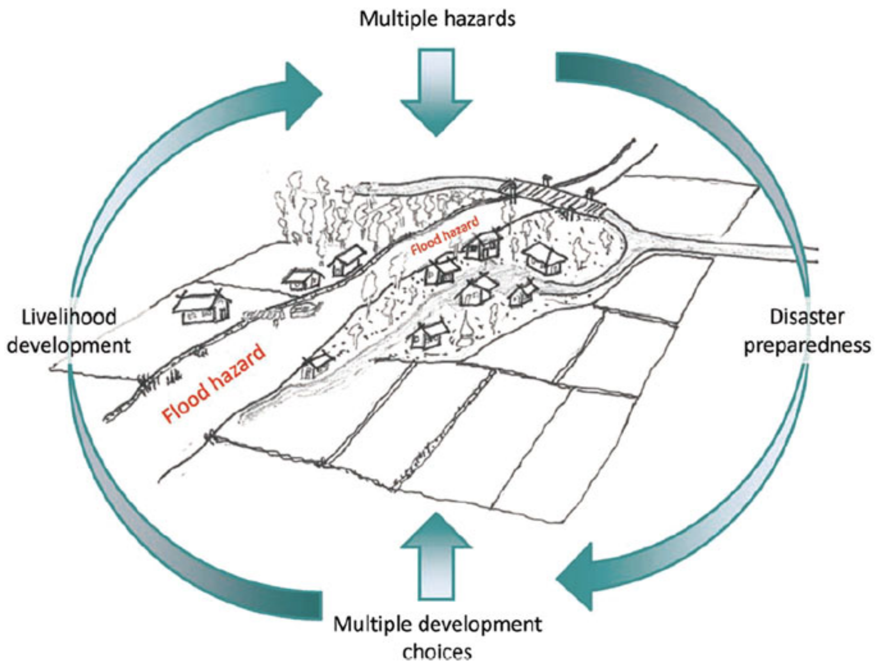

Fig. 17.1 The practice imperative—connecting disaster preparedness and livelihood development. *Figure Source* McQuistan (2015)

to popular belief, judiciously managing flood risk does not have to mean a reduction in economic well-being. Learning to be flood resilient means identifying and taking action where flood risk can be mitigated and development can be enhanced in mutually reinforcing ways (see also Keating et al. 2016a). This involves considering transformational change as part of risk management responses (see chapter by Schinko et al. 2018).

17.1.3 Crafting Effective Science-Society Partnerships that Inform Policy and Practice

How to bring these perspectives together at the different scales that they operate at? In order to inform these policy and practice imperatives there is increasing interest in forging science-society partnership models for effectively managing disaster risks across scales. This particularly holds true for debate around Loss and Damage. We report on one such partnership, the Zurich Flood Resilience Alliance, a partnership launched in 2013 to enhance communities' resilience to flooding at local to global scales. The program brings together the skills and expertise of NGOs, research institutions and the private sector to work to transformation action on managing flood risks. The program uses a participatory and adaptive management approach to develop sustainable portfolios of resilience-building interventions that tackle both flood risk and development objectives in synergy for communities exposed to erosive risks. It has been working in various countries and cases characterised by different challenges and opportunities. The partnership builds its science-society interventions innovatively around a systems perspective for understanding risk and resilience, which takes account of a shifting disaster risk discourse that emphasises disaster resilience as "bouncing forward" and considering transformative approaches (Keating et al. 2016a).

This chapter, reporting and reflecting on the experience of the Alliance in light of the *Loss and Damage* debate, is touching on the following questions: *How to organise such models and partnerships? What are learnings from existing activities? How can learning be upscaled?*

We outline processes and evidence created via a number of case studies conducted as part of the Alliance work. We focus our examination and discussion on two cases, where livelihoods are particularly being eroded by flood risk with amplifications by climate change: (i) in the Karnali river basins in Nepal, communities are facing rapid on-set flash floods during the monsoon season, (ii) in the Rimac basin in Peru communities are exposed to riverine flooding, which periodically is magnified by the El Niño phenomenon.

The chapter is organised as follows: Sect. 17.2 presents the methodological framework underlying the science-society partnership model and our evaluation in this chapter. Section 17.3 presents the Flood Resilience Alliance in some more detail. Section 17.4 outlines methods and models developed, whose applications to the Alliance work and cases is the topic of Sect. 17.5 before Sect. 17.6 finally reflects and derives implications.

17.2 Methodological Framework for Science-Society Partnerships: Implementing a Systems Approach for Dealing with Critical Risks

The methodological framework underlying our further discussion builds on several entry points, which can be aligned using a systems approach. With emphasis on providing useful knowledge for informing sustainability transitions and transformations has come a call to the research community to organise knowledge creation that cuts across scales. As an important key reference, Turnheim et al. (2015) reflect on key analytical traditions and suggests a need for a joint framework and bridging across various approaches. The authors identify 3 dominant research traditions that are of high relevance for the sustainability discourse involving various scales and analytics as well as outcomes and interactions.

1. Coupled human-physical systems modelling to provide broad scenarios for projecting the future along a few decades-applied at global to regional scales;
2. An empirical approach for identifying past and current national patterns and trajectories of change-typically targeting national scales;
3. Locale-specific evidence creation on local initiatives and experimentation taking a backward-looking perspective and often building on heuristics-the local scale.

The literature broadly and the paper specifically emphasise that these methods and models are building on different ontologies and epistemologies. Thus, seamless integration across scales is not possible. Rather, proper boundary processes for effectively aligning these different research traditions are considered conducive in order to provide useful information. Criteria for "usefulness" the following can be generally identified (McNie 2007).

- **Saliency**: Useful information must be salient and relevant to the specific context in which it will be used. Salient information appropriately considers ecological, temporal, spatial, and administrative scales and timeliness.
- **Legitimacy**: Useful information must be legitimate in that those who produce it are perceived to be free from political suasion or bias. This means it is (i) demand driven and involves (experts from) relevant stakeholder groups in the scoping, preparation, peer-review and outreach/communication; (ii) transparent, in that the information is produced and/or transmitted in a way that is open and observable. (ii) builds on relationships between producers and users of the information characterized by mutual trust and respect; (iv) builds social capital through successful relationships and social organization leading to mutual trust, credibility, common rules, norms, reciprocity, and mutual respect.
- **Credibility**: Useful information must be credible and dependable in that it is perceived by the users to be accurate, valid, and of high quality. Peer review is often considered the *sine qua non* of credible information yet in many instances, other types of published information ("grey literature") also can satisfy the credibility criterion.

Importantly, useful information is not only about content, but emerges as the product of an effective process. Useable information needs to have a substantive core in which the information must be useful to the policy maker or actionable for the practitioner. It includes a procedural dimension that provides a mechanism for transmitting knowledge from the scientific community to these different but interdependent worlds. Also, such information provides for agency in terms of social learning and policy-making. We will consider these criteria further on in the discussion.

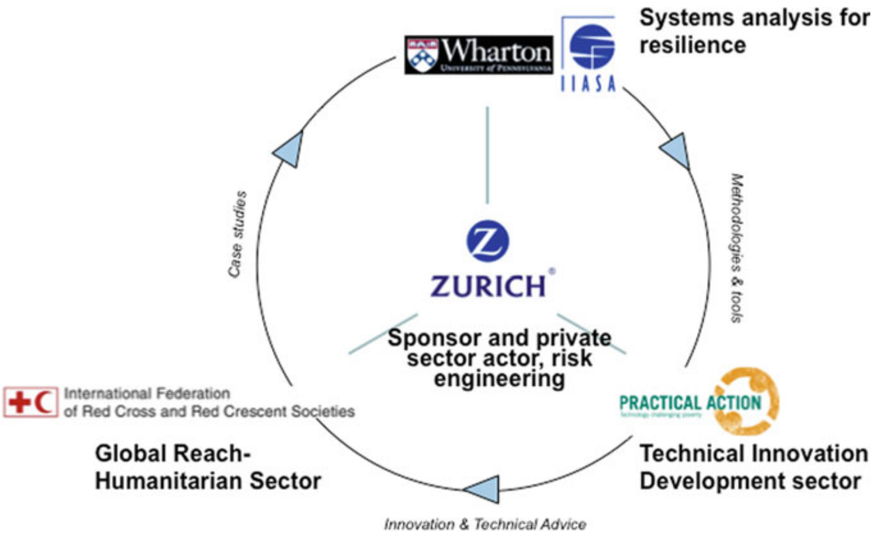

Fig. 17.2 Partners and roles in the Flood Resilience Alliance. *Source* Zurich 2014

17.3 The Zurich Flood Resilience Alliance: A Comprehensive Science-Policy-Practice Partnership

There has been an upspring of partnerships covering the boundary space from science to policy to practice, particularly in relation to disaster risk management, climate adaptation and resilience. The Zurich Flood Resilience Alliance (ZFRA), a unique alliance with leading partners from the development and humanitarian NGO sectors, academia and the private sector has embarked on a journey to help build resilience to flood risk in communities across the globe in order to make a difference for at least 250,000 flood prone households up to mid 2018, households which are often facing erosive risks shaped importantly by climate change. The multi-year initiative set up and co-generated by Zurich Insurance aims to operationalise, measure, and help build the resilience of communities to floods—the most devastating natural hazard globally. This extensive action and research program brings together expertise and skills on risk modeling and systems science as applied by the research partners IIASA and Wharton Business School with risk engineering expertise of Zurich and on-the-ground presence of the International Federation of Red Cross and Red Crescent Societies (IFRC) plus the international development NGO, Practical Action (Fig. 17.2). The Flood Resilience Alliance aims to enhance community flood resilience by exploring innovative ways to reduce risk before a flood strikes. NGO collaborators have used research findings to aid in the design and implementation of interventions to benefit communities.

Focus: Flood Risk

The world is facing increasing risks as globalisation connects people, economies, and ecosystems. Globally, the number of people exposed to floods each year is increasing at a higher rate than population growth. People are drawn to live on flood plains partly because of economic opportunity (World Bank 2013). However, it is increasingly recognised that communities cannot totally avoid risk and that living with risks is the imperative. Future socioeconomic and climatic changes are expected to exacerbate flooding and undermine human wellbeing. Flood risks are increasing, interconnected and interdependent and cannot be enhanced by one stakeholder alone. To date, the development and the disaster risk management (DRM) communities have relied on a mix of interventions to help communities cope with flooding: “hard” interventions like building a dam or flood evacuation routes and, to a much lesser extent, “smart and soft” interventions like land use planning, insurance, and early-warning-systems. Flood-risk management is dominated by single interventions, many of which fail to meet their objectives because they do not consider the wider socioeconomic system within which they operate. In some instances interventions can even be counter-productive in resilience terms, inadvertently undermining development or actually increasing risk in another way.

Focus: A Systems Perspective on Resilience

The engagement in the ZFRA is organised around concepts and methods linked to the notion of resilience. While not a new concept (theory and methods have been developed in the 1970s, importantly coined by thinking on ecological resilience), the resilience discourse has recently been strongly revived, partially also triggered by the aftermath of the global financial crisis. Emphasis in this field has been on identifying synergies with developmental challenges, systemic risks and actions. While some consider resilience the ‘new sustainability,’ it remains to be seen how this promising, if broad conceptualisation may help to stimulate necessary action on climate change and disaster risks, while seeking to foster an integration of social, ecologic and economic dimensions of sustainability challenges. It is well understood that disasters increasingly impair sustainable development, yet DRM has often looked at corrective measures (rebuilding the status quo and old vulnerabilities), rather than prospective efforts tackling underlying risk drivers, such as unplanned urban sprawl and asset location in harm’s way. The concept of resilience provides a chance to take a systems’ perspective and tackle prospective risk creation by integrating notions of up-and down-side risk avoidance and management with upside risk taking. Keating et al. (2016a) document the on-going evolution within the extreme event risk management community towards embracing the concept of resilience. The authors also suggest a novel conceptualisation and operationalisation to help jointly tackle the key challenges discussed above, and see resilience as the “ability of a system, community or society to pursue its social, ecological and economic development and growth objectives, while managing its disaster risk over time in a mutually reinforcing way” (Keating et al. 2017).

Fig. 17.3 Flood risk context in the Karnali river basin in Nepal (left panel) and the Rimac river valley in Peru (right panel). *Photo Sources* Practical Action and A. Keating

17.3.1 Joint Boundary Objects: Case Studies for Co-generating Universal Insights

The ZFRA case studies for co-generating insights and implementing sorely needed projects have been carefully chosen. Case studies are generally characterised by severe flood risk and limits to disaster risk management and adaptation interacting with significant development challenges (see Fig. 17.3).

In the Karnali river basins in Nepal, rural communities are facing rapid on-set flash floods during the monsoon season often leading to massive impacts to lives and assets. Therefore Early Warning Systems, improved disaster management coordination between communities and local and national governments, creation of emergency plans and implementation of alternative livelihoods are part of the interventions. In the Rimac basin in Peru, communities are improving their preparedness for the El Niño season by identifying evacuation routes and emergency plans, capacity building of brigades and supporting communities to engage with local governments on DRR planning.

As well, other case studies, not further discussed here, have focussed on Indonesia and Mexico. Along the Ciliwung, Bengawan Solo and Citarum rivers in Indonesia, there is a huge need to improve waste management, reforestation and to connect the impact of upstream behavioural patterns with flooding in downstream communities. In the region of Tabasco in Mexico, communities located in wetlands with flood seasons lasting for over three months have been in need of improved water and sanitation protection, community centres that can also function as emergency shelters, and new livelihood options that can withstand prolonged flood seasons.

The Flood Resilience Alliance is using a participatory and iterative learning approach to identify and develop for the representative ("universal") cases sustainable portfolios of interventions that tackle both flood risk and development objectives in synergy. The strategies communities use to pursue their development and wellbeing objectives have a profound impact on risk. Likewise, the way a community approaches its disaster risk has a profound impact on development and wellbeing. The trick is to get these two working in a virtuous cycle, rather than undermining each other. Entry points for developing this iterative, cyclical approach are effective community-level processes and a shared vision of adaptive learning discussed in the following.

17.4 Entry Points for Integrating Methods and Models for Putting Flood Resilience into Practice

17.4.1 Participatory Vulnerability Capacity Assessments

For working with communities on implementing DRM activities, the International Federation of the Red Cross (IFRC) and Practical Action use participatory assessment processes to gather, organise and analyse information on the vulnerability and adaptive capacity of communities, which can subsequently be used for joint decision-making. These processes are broadly referred to as Participatory Vulnerability Capacity Assessments (P)VCA. In order to measure vulnerability of communities and households in 1989 Anderson and Woodrow developed the Capacity and Vulnerability Analysis matrix. This largely qualitative, participatory and monitoring approach came to be widely accepted and used by many NGOs in their work on DRM forward (see ActionAid 2005; Davis 2004).

The participatory approaches are particularly valuable in helping to understand the key challenges discussed above namely: (1) The multitude of benefits and local values attached to these; (2) The historical perspective not only in regard to major disasters but also the less intense but recurrent minor shocks and stresses; and (3) Providing an opportunity to link community perceptions including locally-derived knowledge with what science and policy makers are predicting to occur in the future due to existing underlying issues and climate change. This merger of traditional with scientific knowledge adds great value to planning approaches that attempt to consider multiple hazards and accommodate increasing uncertainty.

Overall, VCAs/PCVAs aim to support communities to (i) identify key vulnerabilities of communities; (ii) understand communities' perceived and actual risks; (iii) analyse the resources and capacities available to reduce said risks; and (iv) develop action plans to address identified vulnerabilities and risks. In working with communities on implementing DRR activities, Practical Action has been identifying and estimating the historic and potential natural hazard situation and has been working with communities to estimate the social, environmental and economic losses expected in the area of interest through their PCVA process. These processes are usually completed with the collection of secondary information to provide a baseline of communities' risk to different hazards.

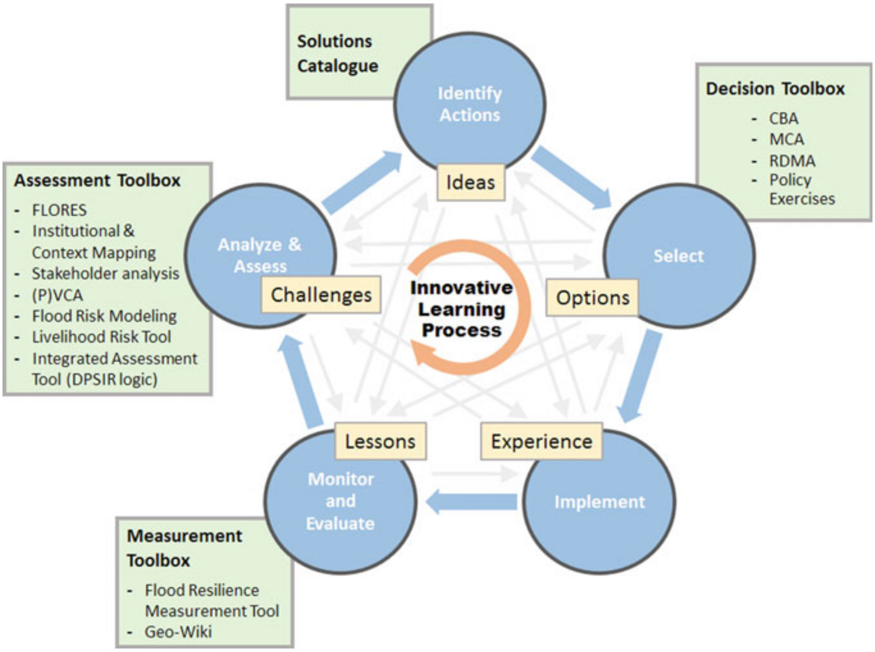

Fig. 17.4 Adaptive management cycle used in the ZFRA to foster Shared Resilience Learning. *Source* IIASA and Zurich 2015

17.4.2 Boundary Processes for the Methodological Framework: Adaptive Management for Shared Resilience Learning

It is well understood that enhancing (flood) resilience is a learning process, which can also be described through an 'adaptive management cycle'. The adaptive management cycle contains the steps required in any process to enhance community flood resilience. In order to link DRM and CCA in practice, the literature has moved towards suggesting a more reflexive-participative approach. Acknowledging the uncertainties and complexities inherent in social–ecological systems impacted by climate-related risks, analysts have started to emphasise iterative and adaptive learning (see, e.g., O'Brien et al. 2012; Mochizuki et al. 2015). Lavell et al. (2012) suggest a learning loop framework that integrates different learning theories, such as experiential learning (Kolb 1984), adaptive management (Holling 1978) and transformative learning (Mezirow 1995). This framework distinguishes three different loops according to the degree that these processes support transformational change of CRM strategies. Figure 17.4 shows the key stages and tools of the learning cycle, which for the Alliance work was termed the "Shared Resilience Learning Dialogue."

Before the cycle is initialised, the first step requires that the organisation(s) driving the development process (including but not limited to NGOs and governments) analyse the situation to identify the development change expected, ensuring that it will address a clear flood risk. The next step is to assess how development and flood risk are linked. This is done together with as many stakeholders as possible. This assessment is designed to explore the current situation, and identify stakeholder's roles and the potential for change. Based on the outcome of this assessment, the organisations select a development plan in line with stakeholders' priorities. This plan will incorporate a suite of solutions to improve community flood resilience. One or more solutions are then chosen as the ones to implement, emphasising a practical ('learning-by-doing') approach.

Those involved in the process monitor and evaluate activities to track how they unfold, test the assumptions upon which the choices were made and see if they deliver results as planned, and to capture lessons that are fed back into assessment. At the centre of the diagram is an iterative learning process, which works cyclically as a loop. This process emphasizes continuous learning and innovation among stakeholders (as opposed to the implementing organisation); the organisation interacts within the 'adaptive' management cycle and ultimately brings about lasting change.

17.4.3 Detecting and Supporting the Management of Risk and Resilience at Scale Around a Learning Framework

For the Loss and Damage discourse and the work reported on in this chapter, we thus propose to employ a learning framework building on risk detection and resilience management. Learning and awareness is fundamental to better understand risk and resilience. The adaptive management framework, as it co-generates insight from local to global scales, can be useful to identify the need for action across time and a scale from incremental (traditional DRR and climate change adaptation) to transformative (fundamentally different livelihood strategies supported by novel policy options), when faced with risks beyond the limits of adaptation. Figure 17.5 links the adaptive learning cycle to a representation of risks today as well as of risks at different levels of warming.

The left panel in exemplary fashion visualises risks and risk tolerance (ranging from acceptable to tolerable to intolerable) for different levels of global warming (complete boxes). The black arrows show the increments to risk with climatic change as a driver. The dashed boxes identify parts of the risk that can further be reduced either by conventional DRR or CCA options (blue-green arrows) or transformative measures as part of responses linked to Loss and Damage (white arrows). The right panel further shows the adaptive management cycle as facilitating single-double and triple-loop learning. It suggests, that in the short-term incremental adjustments to risk and resilience can be taken by (i) monitoring the effectiveness of existing policy

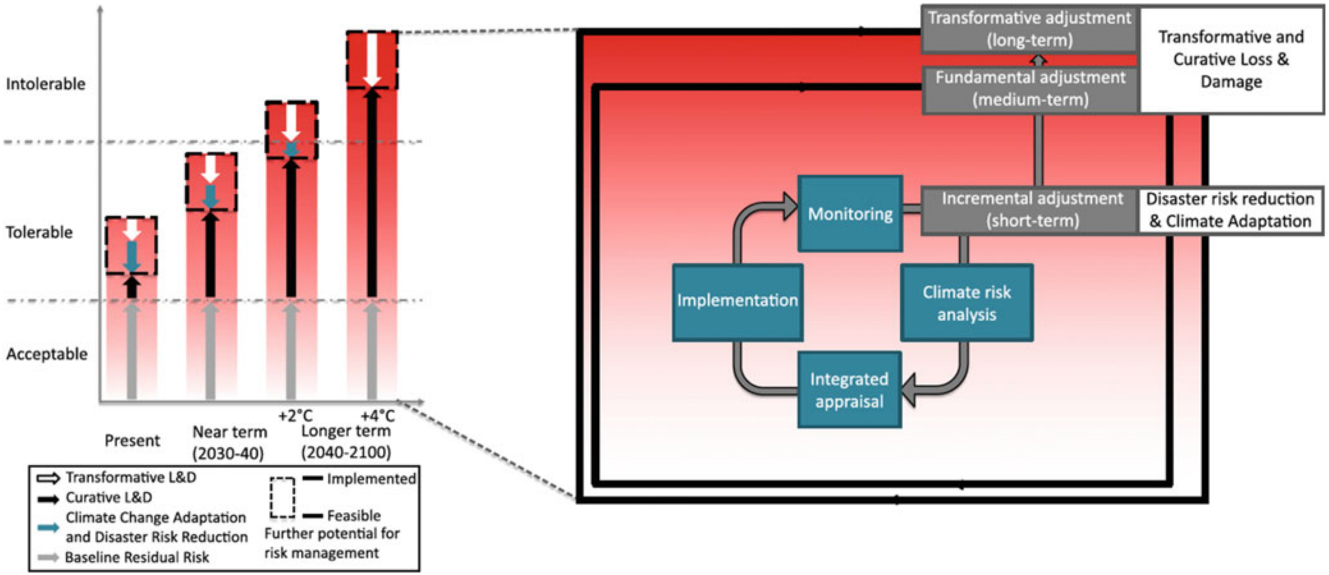

Fig. 17.5 Methodological approach for understanding and learning about risk and resilience. *Source* Mechler and Schinko (2016)

options, scientific evidence regarding climate change, risk and resilience information; (ii) analysis of climate-related risks, such as using flood risk modelling; (iii) appraisals of the resilience of capacities; and (iv) implementation of options and solutions that further build resilience (such as raising flood risk protection). Importantly, going through the incremental adjustment cycle allows for identifying risks beyond standard adaptation calling for fundamental and transformative adjustments. Fundamental adjustment options may be to provide more room for the river, so peak floods levels can be absorbed. Transformative adjustments may involve resettling flood-prone households.

In this fashion, the loop-learning framework sets out a continuous process for identifying and generating sequential adjustment to changing risk and resilience conditions, which benefits the communities at risk as well as, if projected for levels of global warming, provides insight regarding the stresses imposed by climate change, thus underlining the need for stringent mitigation efforts and support for resilience building.

17.5 Application of Methods and Models

We now turn to presenting some of the methods and tools used for the Alliance's *Shared Resilience Learning Dialogue*. As laid out, the Alliance is working with communities in Mexico, Nepal, Indonesia, and Peru in order to design advanced modelling techniques that are robust, user-driven, and user-friendly. The work and findings aim at not only helping communities directly at risk, but also eventually supporting local, national, and international policymakers, NGOs, and donors worldwide to mainstream risk reduction against multiple natural hazards.

17.5.1 Understanding Risk: Risk Geo Wiki and Crowdsourcing

Communities need flood-related risk information to prepare for and respond to floods—to inform risk reduction strategies and strengthen resilience, improve land use planning, and generally prepare for the case when disaster strikes. But across much of the developing world, data are sparse at best and not fit for the purpose for understanding the dynamics of flood risk. The IIASA Risk Geo-Wiki online platform provides for a risk crowdsourcing approach and acts not only as a repository of available flood-related spatial information, but also provides for two-way information exchange. The platform provides digital technology in terms of crowdsourcing and citizen science in order to integrate local/traditional knowledge and expert-sourced knowledge to better understand flood vulnerability of households and communities, scaling up community-level information to river basin level and

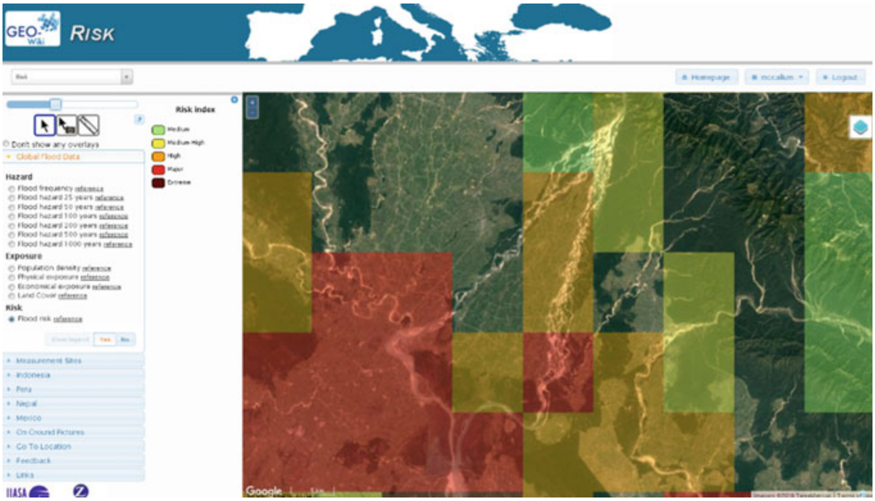

Fig. 17.6 Screenshot of Risk Geo-Wiki. Modelled global flood risk data overlaid on satellite imagery at the regional level for the Karnali, Nepal

more. The portal is intended to be of practical use to community leaders and NGOs, governments, academia, industry and citizens who are interested in better understanding the information available to strengthen flood resilience. This is particularly useful for communities and in locations where accurate topographic maps are not available or the elevation mapping is so course that flood inundation modelling for examples is meaningless.

As a starting point, a variety of global expert-sourced flood datasets (e.g., the GLOFRIS model, Ward et al. 2013) included in the Risk Geo-Wiki can be displayed exhibiting an estimate of flood hazard, exposure and risk based on various flood frequencies/return periods—see Fig. 17.6 for a view of the Karnali basin. This information is a starting point for global and regional analyses to conduct risk-based analysis and broadly identify hotspots.

However, as this figure shows, global expert-based modelled data is by necessity coarse in terms of spatial resolution and often not directly applicable to community level needs. Hence, what is needed is the ability to capture local community level information in a global context.

As introduced, Participatory Vulnerability and Capacity Assessment is a widely used tool to collect community level disaster risk and resilience information and to inform DRR strategies, yet it is not linked to digitised information and broadly available. The Risk Geo-Wiki effort has developed a general methodological approach that combines community-based participatory mapping processes, which have been widely used by governments and non-government organisation in the fields of natural resources management, disaster risk reduction and rural development, with emerging internet-based collaborative digital mapping techniques. The project digitised a set

Fig. 17.7 Community and NGO members mapping into OpenStreetMap with mobile devices in the Karnali basin, Nepal. *Photo Source* W. Liu

of existing maps on disaster risk and community resources where the locations of, for example, rivers, houses, infrastructure and emergency shelters are usually hand-drawn by selected community members. Such maps provide critical information used by local stakeholders in designing and prioritising among possible flood risk management options. Communities in Nepal, Peru, and Mexico have uploaded data to the site and are working on developing it further. For local communities who have uploaded spatial information to the site, it allows them to visualise their information overlaid upon satellite imagery or OpenStreetMap (OSM) (Fig. 17.7).

In collaboration with Practical Action, IIASA researchers worked side-by-side with in-country professionals and communities to demonstrate the value and potential of this general participatory and collaborative digital mapping approach in the flood-prone lower Karnali River basin in Western Nepal. As Fig. 17.8 shows, the new digital community maps are richer in content, more accurate, and easier to update and share than conventional hand-drawn VCA maps. The process engaged a wide range of stakeholders to generate geographic information on resources, capacities and flood risks of pilot communities based on their local needs. This approach, as an inclusive form of risk knowledge co-generation, can make important contribution to evidence-based understanding of disaster risk and thus enhance disaster resilience at all levels. The work has since been taken forward with the collaborators to map communities in Western Nepal, Peru and the Tabasco region in Mexico.

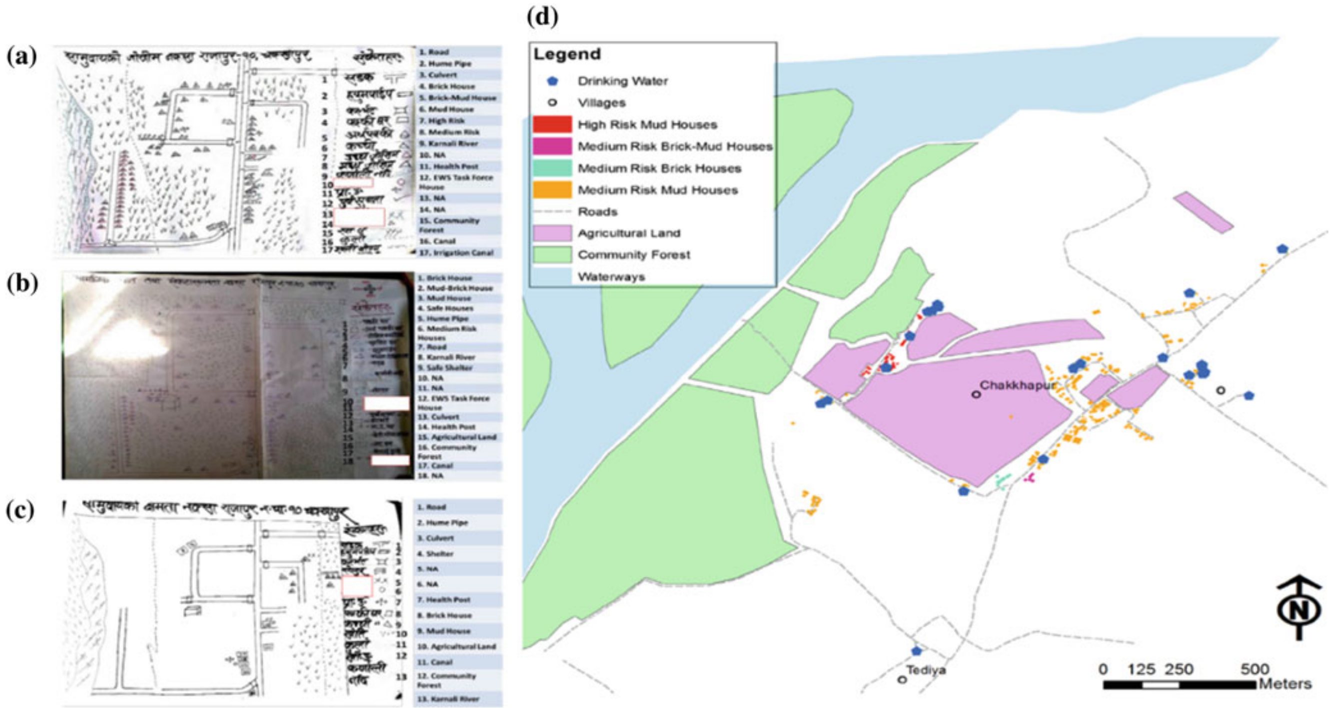

Fig. 17.8 Conventional hand-drawn community risk map, capacity map, and social map versus digital community map produced via a participatory and collaborative mapping approach. *Source* Liu et al. (2018)

17.5.2 Measuring Resilience

Comprehensive risk information is one starting point for guiding disaster risk reduction actions that build resilience. In this regard, a proper understanding of risk in qualitative and quantitative terms is essential, but has not sufficiently permeated resilience research and resilience building to date. Arguably, this is why there has been little concrete, measurable progress on the ground. The resilience measurement initiative of the ZFRA around developing the Flood Resilience Measurement Framework for Communities (FRMC) has been focused on benchmarking and tracking the underlying sources of resilience and the long-term outcomes (see Keating et al. 2017). For the flood-prone communities involved in the study, this means shedding light on why one community may fare better than another in the same disaster, despite seemingly identical levels of development and vulnerability. With the information and resources acquired in this work, communities will not just be able to bounce back after a disaster. They will be able to actually bounce forward in terms of making progress on important development objectives. The tool will help communities and development partners review available options and make judgements on how to build resilience, helping communities with limited resources decide what to invest in, such as increasing and strengthening livelihoods, investing in preparedness measures or building requisite DRR infrastructure.

The FRMC approach to measuring resilience involves measuring the sources of resilience pre and post-disaster, operationalised around key capacity indicators of a community's socio-economic system (Fig. 17.9). The resilience framework, building on detailed literature review aligns resilience systems thinking (Bruneau 2006) with the Sustainable Livelihoods Approach (SLA) adopted by development agencies for broadly tracing achievement of development objectives in communities (DFID 1999). Overall, the approach consistently considers communities‘ assets, interactions and interconnections across, what we call, 5 capitals (or capacities): human, natural, social, physical and financial. The measurement of capital groups builds on a set resilience sources, overall, for the 5 classes there are a total of 88 sources of resilience in this so-called 5C-4R framework. Sources are qualitatively graded from A-D based on available data depending on context and need, e.g. from household surveys, community focus group discussions, expert informants, and other third-party sources. To assure validity of measurement, sources are assessed and graded by specially trained NGO experts embedded in the respective communities, while data are collected globally via an integrated mobile and web-based system. Building on measuring potential resilience of a community, projecting actual outcomes of resilience after an event considers observed impacts (losses and time for getting back to 'normal').

The measurement framework has been rolled out globally, and in addition to the 4 case locations of the ZFRA, other NGOs have been enlisted as additional boundary partners to the ZFRA, contributing data from communities in Afghanistan, East Timor, Indonesia, Haiti and the United States amounting to more than 100 currently graded communities with more than 1 million data points.

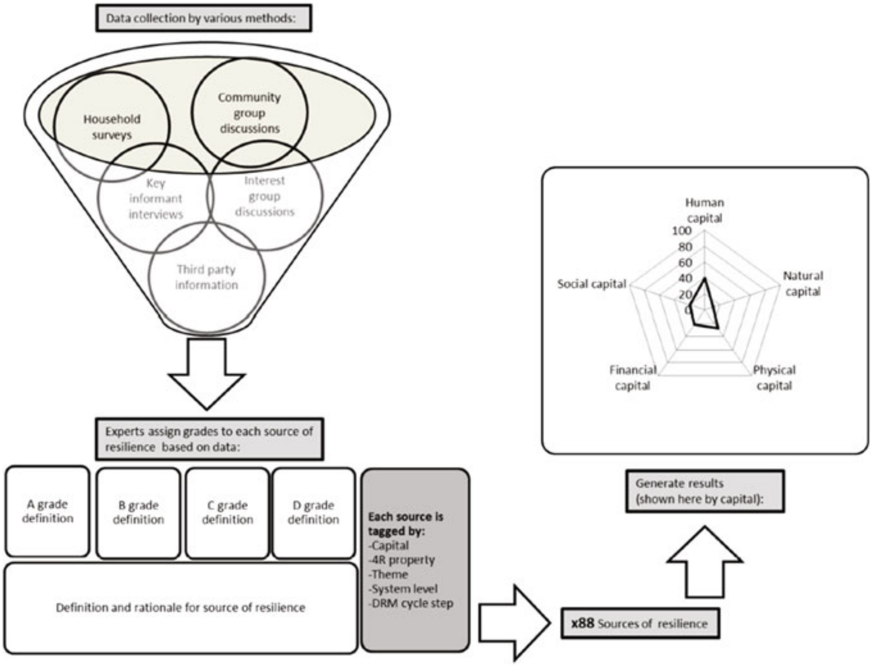

Fig. 17.9 Zurich Flood Resilience Measurement Framework implementation process. *Source* Keating et al. (2017)

The FRMC framework is meant to consistently measure dynamic progress (or lack thereof) over time given internal and external resilience determinants. It can also be applied at a fixed point in time, as done for Nepal in order to statically assess and compare resilience with average resilience across all communities (see Fig. 17.10).

17.5.3 Towards Truly Informing Decision-Making: Decision-Support Techniques

Resilience is generally built by implementing efficient, effective and acceptable measures. There are a variety of decision-support tools for evaluating such options (see Table 17.1). Ultimately, economic efficiency underlying Cost-Benefit-Analysis is only one decision-making criterion of relevance for prioritising DRR flood risk reduction investments. Decisions on investments to increase flood risk resilience are likely to be made based on a number of criteria, some of which are more or less transparent (Mechler 2016). Criteria such as risk-effectiveness, robustness, equity and distributional concerns, and acceptability have been found to be key for deciding on implementing DRR projects. There are other decision support techniques such as

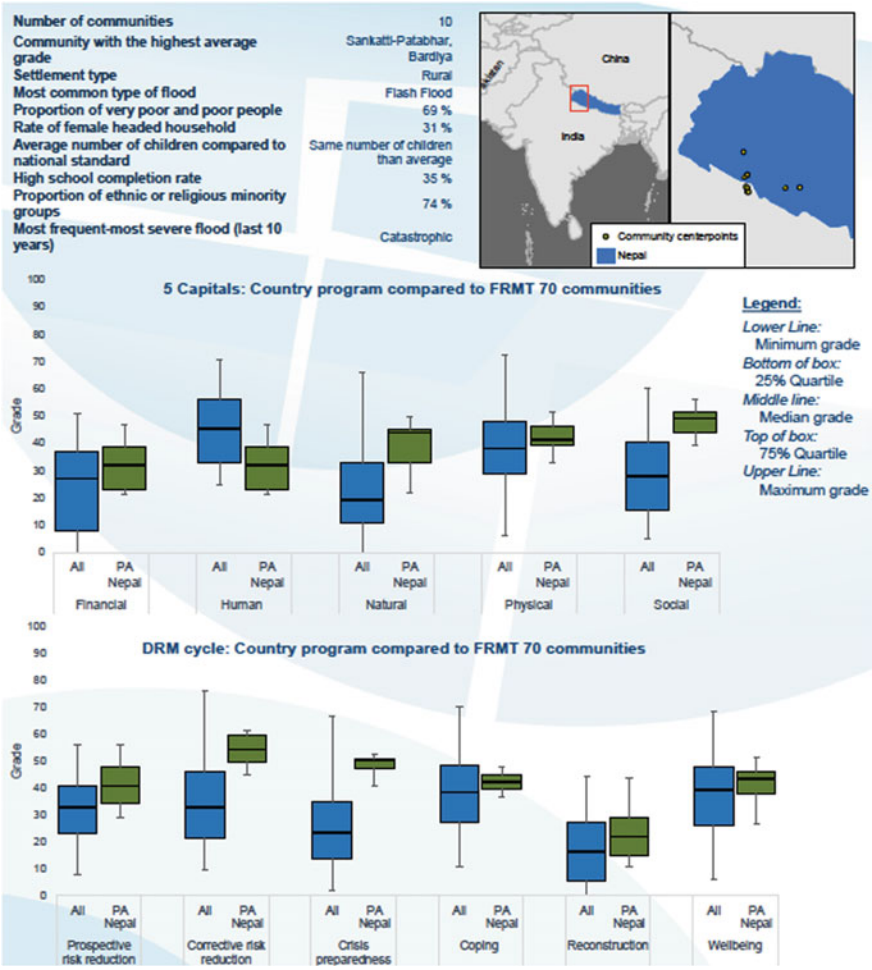

Fig. 17.10 Measuring resilience in Nepal as compared to the global measurement. *Source* Laurien 2017

cost-effectiveness analysis (CEA), multi-criteria analysis (MCA), robust decision-making and serious gaming approaches that can be used to measure achievement of these criteria. These tools can be used to make a more comprehensive case for DRR. As a challenge, they do not lead to easily communicable metrics for presenting the results, such as benefit-cost ratios. These tools inform various types of decisions in many different contexts, including project appraisal, evaluation, informational/advocacy studies and iterative decision-making. Table 17.1 summarises the key advantages, challenges and applicability of CBA, CEA, MCA, robust and gaming approaches. The table illustrates that no tool is perfect for each and every situation.

Table 17.1 Characteristics and applicability of different decision-support tools for ex-ante and ex-post disaster risk management

Decision support tool	Advantages	Challenges	Application
CBA	Rigorous framework based on comparing costs with benefits	Need for monetising all benefits, difficulty in representing plural values	Well-specified *hard-resilience* projects with economic benefits
CEA	Ambition level fixed, and only costs to be compared. Intangible benefits part. loss of life do not need be monetised	Ambition level needs to be fixed and agreed upon	Well-specified interventions with important intangible impacts, which should not be exceeded (loss of life etc.)
MCA	Consideration of multiple objectives and plural values	Subjective judgments required, which hinder replication	Multiple and systemic interventions involving plural values
Robust approaches	Addressing uncertainty and robustness	Technical and computing skills required	Projects with large uncertainties and long timeframes
Gaming/Policy Exercise	Truly engaging stakeholders to inform decisions	Extensive facilitation skills and ability to manage complexity of social interactions	Community level interactions to inform decisions with stakeholders and decision-makers

Note CBA Cost benefit analysis; *CEA* Cost-effectiveness analysis; *MCA* Multi-criteria analysis

Each has its strengths and weaknesses and is suited to different decision-making contexts.

These methods and metrics mostly require some expert facilitation. However, the information-action gap inherent in providing expert input to working with local, national and international stakeholders for selecting options is well known. Failures to produce useful insight often resulted from over-reliance on biophysical data and inadequate appreciation of the diversity of ways decisions are made at all levels of society. Yet, understanding and analysis of complex policy issues is often hampered by the high costs of gathering data about how various members of society actually think and decide about such issues. Similarly, scientists and policy makers often must invest years to gain experience critical to managing systems that change and evolve without undertaking real risk (Sterman 1994). This raises the question: How can we lower the costs of learning through experience? "Serious gaming" and policy exercises (also known as Open Simulations) have emerged to fill this gap (Duke and Geurts 2004). Such exercises use social simulation tools that combine computational models and participation of real actors. Particularly when actions are contested and broad participation in knowledge co-generation and decision-making is required (as is the case for the Loss and Damage discourse), serious gaming approaches become relevant and have been tested and applied in the ZFRA work (see Box 17.1 on serious gaming objectives).

Box 17.1 Objectives of serious gaming to support resilience assessment and building through engagement

- *Demonstrating the benefits of ex ante disaster risk reduction and preparedness.* The game can be used in case studies to test responses of different actors to policy innovations thereby helping to improve them by reducing potential negative side effects. Games can especially draw attention to the 'invisible' indirect and intangible impacts.
- *Fostering flood risk protection through enhancing participatory decision-making.* The game can help stakeholders to build flood resilience buy-in. As a tool it has unique potential to change how people perceive and understand resilience. Through intellectual and emotional engagement in an interactive environment, stakeholders may start to see how important flood resilience becomes for their security and livelihoods. It will also contribute to building social capital by increasing trust and collaboration.
- *Knowledge dissemination and outreach.* Games, by engaging participants, can become a very successful dissemination instrument—with broader outreach than traditional reports. The games developed in the project for stakeholders can be later used for disseminating project insights to broader audience.
- *Supporting the integrated assessment for flood resilience*. Decision-making rules are of the most difficult modelling tasks (either in system dynamics or agent-based models). Gaming exercises can provide a better understanding of decision making of actors that can influence flood resilience. Because they provide context and engage participants emotionally, they are more reliable than questionnaires in eliciting stakeholder responses in a way that can be translated into modelling language.

These exercises mediate collaboration between actors and scientists in analysing how problems emerge in complex systems and where points of intervention may lie. Because they are experienced as something that feels real, more information is retained, learning is faster, and an intuition is gained about how to make real decisions and improve policies. Ideally, if the right actors can be brought together gaming allows the exploration of real issues and provides a neutral platform for different stakeholders to understand conflicting opinions and perspectives in a safe space. The sophistication of the approach allows even non-trained actors to engage in highly complex decisions.

The focus of using policy exercises for the ZFRA, conducted in collaboration with the Centre for Systems Solutions (CRS) in Wroclaw, Poland, has been to apply simulation games and policy exercises to support the activities in the Flood Resilience project. A Flood Resilience Game has been developed, which is a board-game played by 8–16 players, who each take on a role as a member of a flood prone community. Direct interactions between players create a rich experience that can be discussed and analysed in structured debrief sessions. This allows players to explore vulnerabilities, risks and capacities—citizens, local authorities and NGOs together—leading to an advanced understanding of interdependencies and the potential for working together. The game draws on research on the complex challenges of reducing flood risk and fostering sustainable development. It allows players to experience, explore, and learn about the flood risk and resilience of communities in river valleys. Players experience the simulated impacts of flood damage on housing and infrastructure, as well as

Fig. 17.11 Application of the Flood Resilience Game provoking discussion at an NGO workshop in Jakarta

indirect effects on livelihoods, markets, and quality of life. It lets them experience the effects on resilience of investments in different types of "capital"—such as financial, human, social, physical, and natural (see Fig. 17.11).

Finally, players can explore the complex outcomes on the society, environment and economy from different long-term development pathways. This highlights the types of decisions needed to avoid creating more flood risk in the future, incentivising action before a flood through enhancing participatory decision-making. Overall, the learning generated in these interactions in a "safe-space" environment provides a platform for subsequently exploring real-life decisions.

17.5.4 A Systems Model for the Integrated Assessment of Resilience

As an effort to support the development of the gaming approach as well as provide an integrated perspective on flood resilience, the Flood Resilience System Framework and Model (FLORES) has been designed to help provide a first step towards understanding the complexity of the community decision context. The first version of the system dynamics model developed is based on successful collaboration between IIASA and Soluciones Practicas (Peru).[1] The knowledge and experience of Soluciones Practicas' staff has been critical to develop a model that helps to answer

[1]Soluciones Practicas is the Practical Action country organisation for Peru.

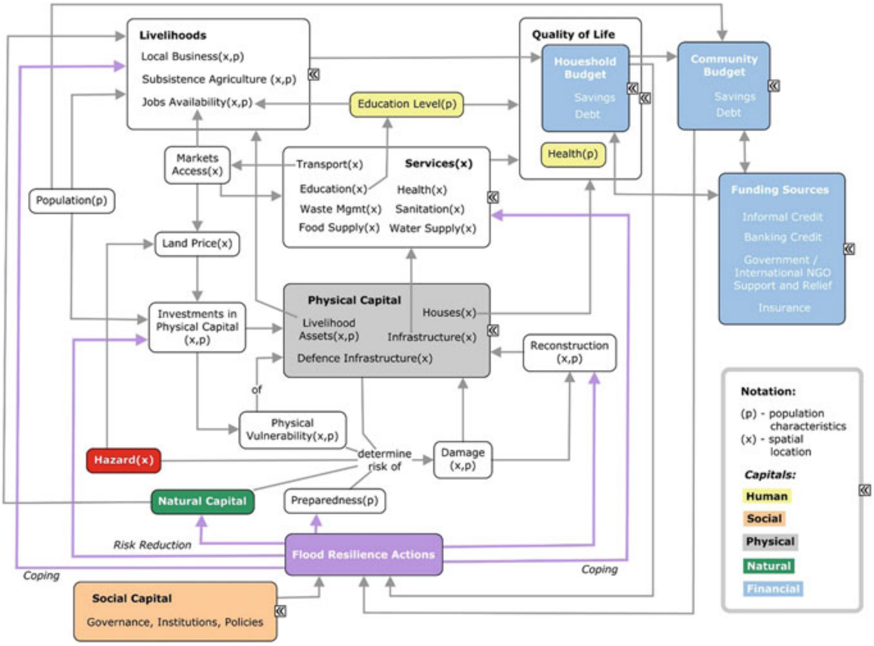

Fig. 17.12 Flood Resilience Systems Framework (FLORES)—a simplified view

strategic questions about improving flood resilience in the Rimac river valley in Peru. FLORES enables users to visualise this complexity to start to learn about how the system behaves, thus helping to unwrap the layers of complexity associated with community-level resilience.

The main purpose of the model has been to explore the medium to long-term dynamics of risk and options for risk management (that is to say: potential hazards and conditions of vulnerability and capacities) of the vulnerable communities with respect to hazardous events (here: huaycos and floods in the Rimac Valley). This perspective has been fundamentally underlying the development of a more comprehensive resilience framework and dynamic model for understanding the relationships. The framework has been discussed and further co-generated with local experts and stakeholders in the Rimac basin in Peru in a workshop setting (see Box 17.2 and Fig. 17.12).

In the case of the Rimac Valley river basin system, community members voiced demand for information that helps to understand how trends in El Nino patterns, climate change, economic development and migration interact with land use, building (new settlements) and transportation in hazard zones and disaster risk reduction activities over a time horizon of 20–50 years. This means different scenarios need to be developed to see how the system will evolve under different policy choices. The system dynamics modelling developed is meant to support interactive simulations (policy exercises), which, in later stages of the community interactions may inform the evaluation and selection of options and solutions.

Box 17.2 The Systems dynamics model FLORES investigates the following problems

- Modelling medium to long-term dynamics of risk (that is to say: potential hazards and conditions of vulnerability and capacities) of the Rimac Valley communities with respect to huaycos and floods.
- Exploring the effects of damages (direct impacts on housing and infrastructure) and losses (indirect impacts) on livelihoods, markets and quality of life, using different modelling scenarios.
- Investigating the influence of different disaster management capacities: emergency preparedness, response, reconstruction, exposure, physical vulnerability (fragility) and risk reduction measures on flood/huayco resilience of communities in the Rimac Valley.
- Analysing the social and economic effects of the El Nino disturbance (including possible migrations) within different climatic and policy scenarios.
- Analysing the effects of institutional arrangements (formal but also informal including illegal settlements, building and transportation) on flood resilience of the Rimac Valley communities.
- Identifying medium-long-term development pathways that avoid creating a flood risk catastrophe (*prospective* risk reduction).

The model is planned to be further used by Soluciones Prácticas staff to explore the critical variables and long-term drivers of resilience and change, and how these interact to produce risk and development outcomes. This might assist in identifying critical entry points (intervention options) for project planning, and to produce advocacy materials/messages to be used in engaging with the disasters and development sectors in Peru. The model has a relatively user-friendly interface and can be computed very quickly, which makes it possible to use it in a workshop setting together with disaster experts or other stakeholders to analyse different scenarios, as well as modify assumptions to produce and examine new scenarios and/or policy options. Modelling workshops can support experts and policy makers to understand the problem space, and develop new, evidence-based policies addressing long-term challenges. Based on the developed model, a policy exercise can be developed where a group of stakeholders can examine step by step the consequences of their decisions, resulting both from the biophysical dynamics and social interaction.

17.5.5 *Understanding Past Impacts for Projecting Future Risk: Forensics and Scenario Analysis*

Projecting future risk and resilience requires a good understanding of observed events and factors driving impacts. Disaster forensics, the study of root causes, has seen increasing attention; as a key work element the Flood Resilience Alliance over the last few years developed and applied its forensic approach, termed Post-Event Review Capability (PERC) to an increasing number of flood disasters around the world[2] (Venkateswaran et al. 2015; Keating et al. 2016b; Zurich 2014a, b, 2015a, b). The point of departure for disaster forensics, an inter- and transdisciplinary research effort, has been the understanding that the wealth of disaster risk information available has not been sufficiently effective to help halt the increase in risk. A number of propositions have been suggested by forensics to work towards actionable information to reduce risk and build resilience-all of which are of fundamental importance for the *Loss and Damage Debate* (see IRDR 2011): (i) *Risk reduction*: More probing research coupled with actors' roles visibility and transparency will lead to increased investment into risk reduction; (ii) *Integration*: More integrated (inter-and transdisciplinary) and participatory research will produce more useful and effective results; (iii) *Identification and Communication of Risk Management Roles*: More effective and sustained communication of findings is required.

One entry point for taking retrospective disaster forensics forward to inform Loss and Damage tackled in the Alliance has been to explore its integration with prospective scenario analysis. Scenario analysis is a technique and structured process for projecting out key variables of interest (in this case disaster risk and resilience) as a function of its drivers based on shared narratives about future socio-economic development and other inputs. Scenario analysis has been widely used for global problems (e.g., IPCC climate scenarios) as well as applied in local-participatory context to explore solutions to local problems (Notten et al. 2003). It has neither been widely used for problems related to disaster and climate-related risks nor applied in forensics studies. Building on substantial forensics work undertaken in the Alliance, we tested a forensics approach for understanding and dealing with the impacts brought about by the El Nino Phenomenon in Peru in 2016/17 (see French and Mechler 2017).

The El Nino Phenomenon generally and particularly in Peru has brought about large disaster impacts about the affected. Impacts are recurrent and highly variable, with a cycle of 7–14 years. Other hazards interact and recently a so-called coastal El Nino hit Peru leading to major devastation (Fig. 17.13). The forensics work, building on other PERC and disaster forensics studies (Venkateswaran et al. 2015; Keating et al. 2016b), and utilising desk-based research and analysis, semi-structured and unstructured key-informant interviews, empirical risk analysis and risk modelling, took the large uncertainty associated with El Nino as a point of departure in order to better understand the history and future evolution of El Niño impacts and linked DRM efforts in Peru. The research has been building on empirically grounded insights and

[2] see www.floodresilience.net/solutions/collection/perc.

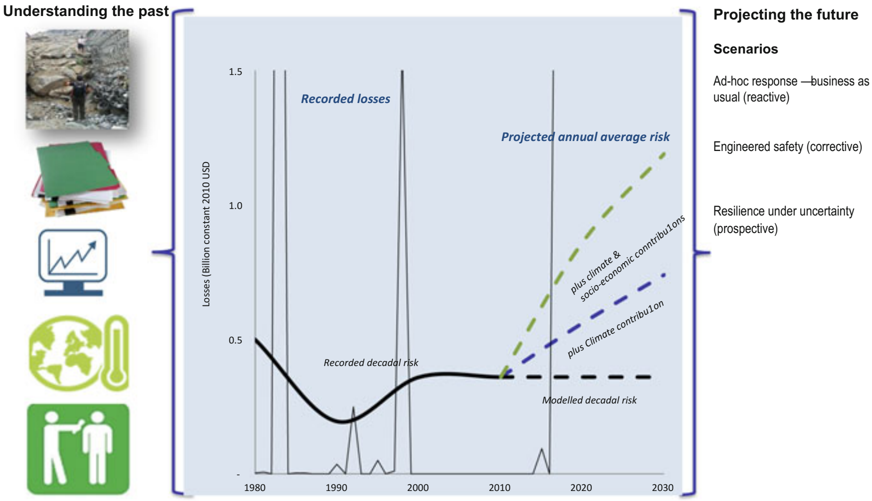

Fig. 17.13 Prospective forensics for projecting flood risk in Peru. *Source* French and Mechler (2017)

learning from past experience in order to identify future resilience pathways. It went beyond analysing the discrete events of 1997–98 and 2015–16 to understand the evolution of the key risk drivers hazard, exposure and particularly vulnerability over the past and the future using a scenario approach. This forward-looking analysis, termed projective forensics, thus linked retroactive PERC assessment with a future-oriented scenario approach for risk and resilience building for flood risk in Peru. As guiding question the team asked was: *Given the risk drivers and actions implemented or considered, how would future risk in Peru evolve over the short to medium-term horizon-up to 2030 as compared to today and what additional actions to take?*

Building on risk projections given by a prominent flood risk model (Ward et al. 2013) to also consider the socio-economic portion, trends identified in the past were used to project the future using different scenarios as detected locally: (i) *Ad hoc response* (reactive)-only prioritising DRR when an event is predicted/imminent; (ii) *Engineered safety* (corrective)-investing in hard infrastructure projects; and (iii) Resilience *under uncertainty* (prospective)-investing heavily in planning, zoning and relocation. As shown in Fig. 17.13, future risk associated with these pathways differs markedly. None of these scenario projections is likely to exactly see implementation, yet they provide a projection space, and thus may, as one application, support gameful policy exercises, help to identify and motivate further actions today and in the short-medium-term for building resilience.

17.6 Reflections and Implications: Providing Insight at Scale for Detecting and Managing Erosive Risk

Our reflection on the ZFRA experience started out by asking how analytical methods and tools can be co-generated and used by experts, practitioners and those at risk in order to build resilience against climate-related hazards (here flooding). Employing an adaptive management learning framework (the *Shared Resilience Learning Dialogue*) as the boundary process for integration, we presented a variety of different demand-driven tools and methods co-generated and used at different learning stages and across temporal and agency scales in this science-society partnership. Figure 17.14 graphically charts out the various tools and methods across time and agency scales. Many tools focus on present and future insight, while PVCA provides evidence on past identification of hazards and risks, and the forensic scenarios work from the past to projecting the future. Community-level tools, such as PVCA, crowdsourcing, resilience measurement 'speak' to efforts positioned at higher agency levels, such as the Risk Geo-Wiki and flood risk modelling. Gaming exercises and the FLORES model are nested between scales as potential connectors between global and local insight. Seamless integration of the tools and methods is often not possible, but the *Shared Resilience Learning Dialogue* generated throughout the partnership provides the boundary process that connects the different tools and methods, and particularly links these up with community-led processes.

The Zurich Flood Resilience Alliance is further gaining knowledge and experience to use these tools to enhance community flood resilience. The tools outlined here are being refined in joint collaboration with partners Practical Action, IFRC and Zurich insurance and other boundary partners working with the Alliance. The tools are compatible with, and being applied in conjunction with established community

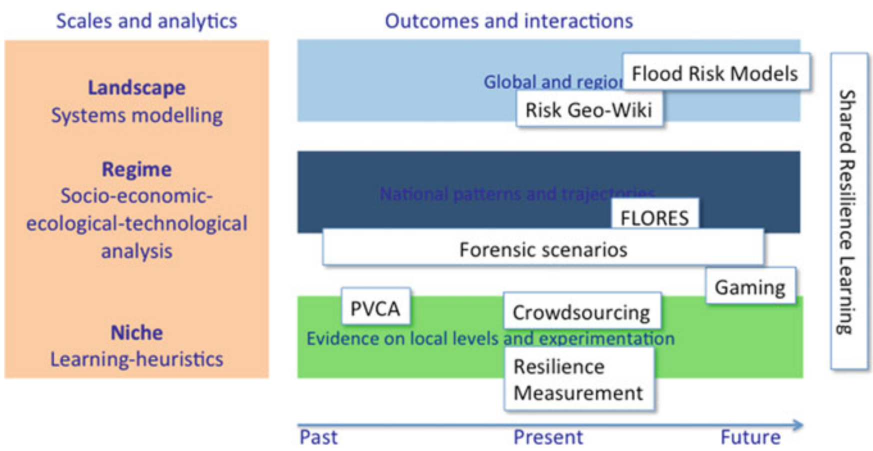

Fig. 17.14 Tracing methods and tools developed in the Zurich Flood Resilience Alliance in time and space connecting risk and resilience research with practice

initiative process-based tools such as vulnerability and capacity assessment, participatory capacity and vulnerability analysis, stakeholder mapping, hazard mapping and vulnerability assessments, household economic analyses, political economic analysis, etc. The ZFRA case studies all deal with marginal communities that have to face erosive flood-related risk in Nepal, Peru, Mexico and Indonesia. The charge is to support incremental with fundamental and transformative adjustments across the risk spectrum to support DRR and CCA practice as well as Loss and Damage policy debate. Global policy, such as on Loss and Damage is increasingly faced with demands for local, i.e. subnational to community-level engagement to deliver "on the frontlines of climate change." The partnership model described shows one effective model for doing so. It also shows that seamless integration of tools and methods across partners is neither feasible nor desirable. It is not fully feasible, as partners follow different theories of change building on differences in ontological perspectives. It is not desirable as these differences in worldviews are mutually enriching and conducive for action at appropriate scales (local to global). The lack of seamless integration can be effectively dealt with by the adaptive learning approach implemented through the Shared Resilience Learning. Continuous learning for partners and stakeholders allows for identifying options and solutions that work across scale, are acceptable, efficient and above all, effective for those dealing with increasing risks from climate change now and in the future.

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