The PERC manual

Learning from disasters to build resilience:
A guide to conducting a Post-Event Review – (2020)

Contents

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This article reflects the personal views of the authors and does not necessarily represent the positions of the organizations they work for on any of the issues discussed.

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Foreword

In our complex, interdependent, fast-paced society, there is often little time to look back and reflect on what has happened, and more importantly, why it has happened. Learning why something has manifested in the way it has is fundamental to improving how we do things — learning allows us to recognize what worked well and what didn't and adapt our processes. It is easy to keep on doing what we always have done and not realize the opportunities to do things better.

There are various stages of learning. Having been involved myself in many of the post-event reviews has shown me that we can always go deeper, beyond just picking up the easy or obvious pieces of deterministic information lying on the surface. A PERC researcher is a bit like a child asking "But why…" in response to any answer received. I find that taking this approach – listening to what others have to say, learning from their experience, encouraging them to think a bit differently and look a bit deeper – and then combining the individual puzzle pieces until a bigger picture emerges is still the unique value proposition that PERC brings. It is rewarding to see interviewees discover additional perspectives and thinking about different solutions solely by probing and asking open-ended questions. It is equally rewarding when the final range of products comes together to present not just the findings, but why we discover those findings and what can be done to address them.

This is why disaster forensics is so important and a key emerging field. It is amazing to see how much progress our own PERC approach has made since we started in 2013. Who would have thought then that what started as a small idea within the broader Zurich Flood Resilience Program would turn into what it has become today: a multiple award-winning concept spanning five continents; a tangible approach that supports disaster risk reduction programming on the ground; a set of strong, recurring insights that help advocate for doing better from the local to global scale; and a grounded methodology with results supporting peer reviewed articles and book contributions.

PERC's systematic, credible foundation has allowed us to expand the method from its "home base" in the flood context to other natural hazards. This, in turn, has allowed us to build up an ever-growing stock of insights and recommendations on the Zurich Flood Resilience Alliance Knowledge Portal[1] which detail how to take action so that large events do not necessarily have to turn into humanitarian disasters. This work helps us maintain the drumbeat that disasters are not natural, that risk reduction and building resilience can make a big difference and, if done at the right time and place, reducing risk and avoiding harm is cost-effective and eminently achievable. We simply need the motivation to act.

We did not know at the outset what our small team working on PERC would get themselves into – and with every new post-event review, we still don't know. It is part of the task to jump into the unknown and learn from what we find there. I want to thank all of individuals, teams and organizations who have tirelessly worked with us and supported us along the PERC journey and who have been integral contributors to the awards we have received – the Outstanding Achievement Award from the 2019 US National Hurricane Conference, and the 2019 Business Insurance Innovation Award. Clearly, providing learning is vital to improve the functioning of our society, and we must make every effort to keep learning open-access, easy and free to obtain. Both our flood resilience portal and the PERC are here to be shared with all of you, and this is why I am happy to launch this new, updated version of the PERC Manual.

Zurich, August 2020
Michael Szönyi, Flood Resilience Program Lead
Zurich Insurance Company Ltd.

[1] https://floodresilience.net/perc

What is a PERC?

The Post-Event Review Capability (PERC) provides a process and framework for the systematic analysis of a disaster event, focusing on how a specific hazard event became a disaster. The Zurich Flood Resilience Alliance ("Alliance")[2], launched in 2013, created PERC as part of Zurich's sustainability function. PERC builds on the field of disaster forensics to systematically and holistically analyze disaster events and what led to them, and to identify actionable recommendations. It is typically conducted and published within a year of the event, though it can be used in other ways or in other timeframes as necessary. PERC evaluates the successes and failures in the management of disaster risk prior to the event, disaster response, and post-disaster recovery. If the event occurred in two different areas with one more severely impacted than the other, PERC can help determine why the impacts were disproportionate. PERC then identifies future opportunities for intervention/action that could reduce the risk posed by the occurrence of similar, future hazard events.

PERC uses a system-wide approach to review disasters, analyzing across scales and sectors, and all five aspects of the disaster risk management cycle—prospective and corrective risk reduction, preparedness, response, and recovery. It provides a bird's-eye view of why the event manifested in the way it did and how resilience might be built. While most PERCs to-date have primarily focused on floods, the PERC can be applied to review any rapid-onset shock, natural or non-natural, such as floods, earthquakes, tsunamis, terrorist attacks, and so on. To date, 18 PERCs have been conducted (Table 1) on a variety of flood types including river floods, flash floods and tropical and winter storms that led to catastrophic flooding in both urban and rural settings and in global contexts ranging from least-developed to most-developed. In addition, the methodology has recently been expanded to include three reviews of wildfire events.

Table 1. Overview of post-event reviews conducted to date (August 2020), including the geographies addressed in each study and the date of the hazard event

PERC report	Geography	Event timeframe
1 – Central European floods 2013: a retrospective	Germany (focus), Austria, Czech Republic, Switzerland	June 2013
2 – Floods in Boulder: A Study of Resilience	United States	September 2013
3 – After the storm: how the UK's flood defenses performed during the surge following Xaver	United Kingdom	December 2013
4 – Balkan floods of May 2014: challenges facing flood resilience in a former war zone	Bosnia and Herzegovina, Serbia, Croatia	May 2014
5 – Emmental, Switzerland floods of July 2014: On a hot, sunny day, a flood alert!	Switzerland	July 2014
6 – Urgent case for recovery: what we can learn from the August 2014 Karnali River floods in Nepal	Nepal	August 2014
7 – Morocco floods of 2014: what we can learn from Guelmim and Sidi Ifni	Morocco	November 2014
8 – What can be learned from the Columbia and Charleston floods 2015	United States	October 2015
9 – Flooding after Storm Desmond	United Kingdom	December 2015
10 – Southern Germany Flash Floods	Germany	May/June 2016
11 – Managing El Niño risks under uncertainty in Peru	Peru	2016
12 – Learning from El Niño Costero 2017: Opportunities for building resilience in Peru	Peru	2017
13 – Houston and Hurricane Harvey: A call to action	USA	August 2017
14 – Hurricane Florence: Building resilience for the new normal	USA	September 2018
15 – Fort McMurray Wildfire – Learning from Canada`s costliest disaster	Canada	2016 – 2017
16 – California fires: Building resilience from the ashes	USA	2017 – 2018
17 – When the unprecedented becomes precedented: Learning from Cyclones Idai and Kenneth	Malawi, Mozambique, Zimbabwe	March – April 2019
18 – The Southwest Tasmania Fires of Summer 2018-2019 (forthcoming)	Australia	December 2018 – March 2019

[2] The Zurich Flood Resilience Alliance is a multi-sectoral, long-term and flexible partnership of academic, humanitarian and private sector organizations focused on helping communities in developed and developing countries strengthen their resilience to flood risk.

the PERC methodology has been developed in collaboration with independent scholars in the disasters field.

Common themes appear within the existing body of PERC analyses, with similar points of failure, successes, and capacities in anticipation of and response to natural hazard events across geographical, social, political and economic contexts (see Section 6 for more detail on common themes and lessons). This suggests that any place on the globe can provide important, broadly applicable lessons regarding where and how resilience can be built. These lessons are critical; 'learning' is the cornerstone of the resilience-building process. As we know, after the event is before the next event. Learning, and acting on that learning, is needed to avoid rebuilding the same risks or building-up more risk, and to reduce loss and misery in future events. A comprehensive analysis of the post-event reviews conducted to date highlights both the commonalities and specificities of individual disasters that have been the focus of PERC studies. The findings have been published in peer-reviewed publications (Keating et al, 2016; Szoenyi et al, 2017; Venkateswaran & MacClune, 2020) and in products for both general and insurance-focused audiences (Zurich Insurance Group, 2019).

PERC is research independent from political reviews, and other vested interests, implemented to understand what happened during the event and why. While Zurich Insurance is behind the PERC, the methodology has been developed in collaboration with independent scholars in the disasters field. PERC research is independent from insurance coverage and products. Given that PERC is designed to provide a holistic analysis of a disaster, from local to trans-regional or trans-national findings, study results are not a priori aimed at decision-makers or actors at any specific level, nor targeted at specific sectors. PERC is also not a Post-Disaster Needs Assessment (GFDRR 2013[3]); it does not design or recommend specific interventions or provide a framework for recovery. Though PERC recommendations are necessarily broad, they are context-specific, and provide practitioners, authorities and advocates with actionable entry points for promoting, planning, designing, and executing interventions that are grounded in the local context.

This manual is not a step-by-step protocol. Rather, it provides a process, in the form of a set of guidelines, ideas and suggestions for conducting PERC fieldwork, coupled with a framework for organizing, analyzing and presenting findings. The PERC process and framework can be adopted and modified to suit the context being studied, meet pre-defined and emerging needs, and ensure that the most accurate and representative review possible under typical constraints (time and financial resources) is conducted. This manual is available free of charge for anyone who wishes to use the PERC.

In this updated, Version 2 PERC manual, we incorporate the lessons we have learned over the course of PERCs conducted since 2013. We provide more detailed guidance on how and where to apply a post-event review and how PERC recommendations can be actioned and implemented in disaster-prone contexts. We lay out the PERC approach for individuals and organizations looking to conduct a systematic and holistic evaluation of a hazard event or disaster. In Section 2 we focus on the framework that PERC is based on. In Section 3 we break down the PERC process and discuss how to obtain needed information. In Section 4 we provide guidance for organizing and analyzing the data. In Section 5 we discuss ways to use PERC findings. In Section 6 we discuss some common, recurrent findings and issues we have seen across the range of contexts and geographies in which we have conducted PERC studies. In Section 7 we conclude the manual by reiterating the goals and benefits of the PERC and reemphasizing PERC strengths and flexibility. Throughout we have streamlined the language and simplified the explanations with the goal of making the PERC approach more accessible and usable. We have included new information on adapting the PERC to new hazards, on incorporating future scenarios in PERC evaluations, on utilizing PERC results, and on the common lessons learned from the PERC studies that have been conducted to date globally.

We hope that future PERCs—whether conducted by the Zurich Flood Resilience Alliance or others who are enticed by the concept—will contribute to our growing library of PERC lessons. Our goal is to create something more than just the sum of the individual PERC reports on a shelf; we have developed an open-access collection of all the specific learnings on our Zurich Flood Resilience Alliance Knowledge Portal[4]. Decision-makers, planners, practitioners and researchers globally can draw from this collection to better understand disasters, design interventions, and build resilience in their own locales. We do not need to wait for major disaster events to catalyze action; rather, we can learn from the experiences and knowledge gained from disasters elsewhere to prevent hazards from becoming future disasters.

[3] http://www.recoveryplatform.org/pdna (retrieved August 2020)

[4] https://floodresilience.net/perc

2 The analytical foundations of the PERC

PERC focuses on the resilience of people, systems, and legal and cultural norms before, during, and after an event. The Zurich Flood Resilience Alliance's definition (Keating et al, 2017) of disaster resilience is:

"the ability of a system, community or society to pursue its social, ecological and economic objectives, while managing its disaster risk over time in a mutually reinforcing way".

Achieving this requires both the ability to learn from the disturbance and to incorporate risk into decisions about future investment. As resilience declines, the magnitude of a shock from which the system can recover gets smaller and smaller. In contrast, a resilient system avoids the creation of more risk, addresses the current risk, and is forgiving of shocks when they do occur.

Resilience goes beyond simply recovering from a shock to the pre-shock state; in particular, bouncing back to a previous, 'stable' state is problematic if that state was vulnerable to begin with. Rather, resilience implies 'building back better', such that future shocks have a lesser impact. Ultimately, disaster resilience is about living—and thriving—in the face of disaster risk.

In a PERC study, the analysis and narrative of what happened and why are structured around the disaster risk management (DRM) cycle. We define five stages of the DRM cycle: preparedness, response, recovery, prospective risk reduction, and corrective risk reduction.

- **Risk reduction and preparedness** – This is the 'before' part and is about minimizing disaster risk. It includes the three steps of prospective risk reduction, corrective risk reduction and crisis preparedness.
  - Prospective risk reduction is the action taken to avoid the build-up of more risk.
  - Corrective risk reduction is action taken to reduce existing risk to already at-risk people and assets.
  - Crisis preparedness includes 'preparedness for response' and community or localized awareness and action to help mitigate or avoid impacts when an event occurs

  Both prospective and corrective risk reduction tend to focus in particular on long-term processes, land use, and infrastructural change.
- **Response** – This is the 'during' part and is about all the actions taken during and immediately after an event to contain or mitigate impacts, such as evacuation, search and rescue, and emergency relief distribution.
- **Recovery** – This is the 'after' part and is about the actions taken after the event (either in the short- or long-term) to help people cope with or recover from impacts, reconstruct damaged physical systems (e.g., roads, homes, businesses), restore services for users, and improve policy to better deliver disaster management and disaster risk reduction. Recovery and "building back better" is an opportunity to tackle both aspects of corrective and prospective risk reduction using lessons learned to ensure that the next event does not turn into the same disaster as the previous one.

The concept of the DRM cycle is useful for organizing thinking throughout the PERC process. PERC recommendations tend to be structured around this concept, since actors often are responsible for the implementation of a specific time-step element of the DRM cycle. For example:

- Weather service, flood forecasting and river authorities deal with early warning and preparedness;
- Public emergency services such as fire brigade, police, civil protection or technical assistance organizations operate in the response phase;
- Reconstruction efforts implemented by reconstruction cabinets, public works, faith-based and non-profit recovery support, and insurance claims handling all take place in the recovery phase;
- Environmental, planning, and land zoning offices often deal with prospective risk reduction; and
- Authorities, agencies and stakeholders tasked with maintaining or enhancing building codes, testing and standardizing protection equipment and installations, or incentivizing the uptake of protection measures are all conducting corrective risk reduction.

While it is useful to structure the PERC process around the DRM cycle, the analysis of what has happened within each of the components of the cycle and identifying lessons learned is done using a resilience lens. In the PERC, the resilience lens consists predominantly of two conceptual frameworks – the Five Capitals framework[5] and the Systems, Agents, Institutions framework (Tyler & Moench, 2012). These two frameworks are utilized in conjunction to provide a more granular analysis and support a deeper understanding of why the hazard manifested in the way it did and the long-term implications for communities. This, in turn, supports the development of more clearly

[5] DFID's Sustainable Livlihoods Framework. DFID's "Sustainable Livelihoods Guidance Sheets" are downloadable from the web, together with a broad range of further up-to-date information on livelihoods (www.livelihoods.org).

targeted recommendations. While these frameworks are conceptual and require practice to fully grasp, they enable a depth and quality of analysis that is otherwise difficult to achieve.

The Five Capitals framework (see Box 1), adopted by the Zurich Flood Resilience Alliance, is useful for ensuring that the PERC develops an understanding of the local context and hazard event and generates lessons learned and recommendations that are, in sum, holistic, interdisciplinary, and multi-sectoral. The five capitals – physical, financial, human, social, and natural – are broad categorizations of types of systems, services, and knowledge that people require to be resilient. Gaps in these capitals are often indicative of tangible entry points for building resilience. For example, households and communities in rural areas may have less access to money for recovery (financial capital). In these contexts, relationships with nearby family, neighbors, and friends (social capital) are critical for sharing resources (financial capital) and skills (human capital).

Box 1. The Five Capitals of the Sustainable Livelihoods Framework

The Five Capitals (5Cs) comprise of a set of measurable indicators and are grouped as follows:

- **Physical** – the things produced by economic activity from 'other' capital, such as infrastructure, equipment, improvements in crops, livestock;
- **Financial** – the level, variability and diversity of income sources and access to other financial resources that contribute to wealth;
- **Human** – the education, skills and health of the people in the system;
- **Social** – social relationships and networks, bonds that aid cooperative action, links to exchange and access ideas and resources; and
- **Natural** – the natural resource base, including land productivity and actions to sustain it, as well as water and other resources that sustain livelihoods and wellbeing.

The Zurich Flood Resilience Alliance has developed and applied a Flood Resilience Measurement for Communities (FRMC) – https://floodresilience.net/frmc – based on these five capitals (a concept which has been drawn from the Sustainable Livelihoods Framework, see Knutsson & Ostwalk, 2006) and other ways of parsing resilience. The FRMC is designed for organizations working with flood-prone communities to help: 1) analyze the current situation and determine where in the local context resilience can be built pre-event to reduce potential loss of lives and assets during a hazard event; 2) measure if and how outcomes of resilience have manifested during and after a hazard event; and 3) evaluate if and how community-based initiatives and risk management strategies are delivering on their promise of building resilience. There is no one-size-fits-all solution to resilience building, and as such local context is critical. This local context is provided by an in-depth analysis of the five capitals. See Table 2 and Box 2 for more information on what the FRMC is and how it links with PERC.

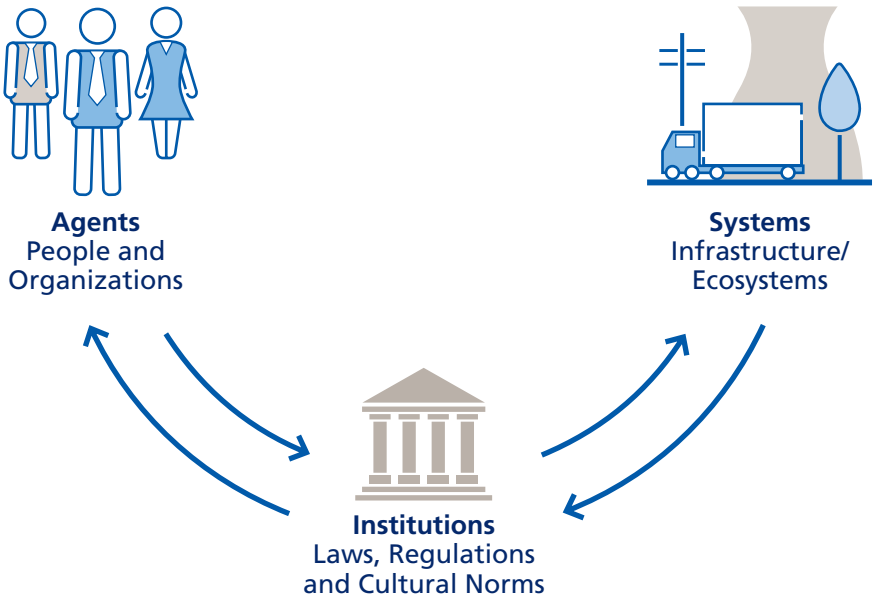
The Systems, Agents, Institutions framework (see Figure 1) focuses on people, their needs, and the cultural and legal norms that enable (or constrain) their ability to thrive. The components of this framework are necessarily broad, but help dig deeper into *how* people interface with critical systems to create or reduce risk (Friend & MacClune, 2012):

- **Systems** – This is the 'what' component of resilience. It refers to a combination of ecosystems (natural capital) and infrastructure systems (physical capital and financial capital) and the services they provide. Ecosystems provide basic foundational needs (water, air, food) as well as some more advanced needs such as coastal defense, and water absorption capacity. These ecosystem services are mediated, either positively or negatively, by physical infrastructure and services (e.g. transport, water distribution, drainage, power and communications) that are central features of human settlements.
- **Institutions** – This is the 'how' component of resilience. It refers to the rules, norms, beliefs or conventions that shape or guide

human relations and interactions, access to and control over the five capitals. While institutions shape agents—equally, agents are able to shape institutions, thus opening the possibility of change.

- **Agents** – This is the 'who' component of resilience and includes social and human capital. It refers to people and their organizations, whether as individuals, households, communities, private and public sector organizations, or companies, and their capacity to respond to and shape the world around them. Agents have different sets of assets, entitlements, and power, that enable or constrain access to systems.

Figure 1. The interacting components of a resilient system



When applying these two frameworks to guide the analysis, it is critical to remember that systems, agents, institutions and the five capitals are not operating in isolated silos; rather, they are dynamic and constantly interacting with one other. For example, physical infrastructure such as levees, by themselves, do not build or inhibit resilience; what is key is how people interact with levees under a set of norms and rules, and how and why the levee impacts other systems that people depend on. Does the levee attract development towards it (the levee effect, Tobin 1995)? Do land use policies govern development near the levee, and are they enforced? Who lives outside the levee and who lives inside? How does the levee change people's behavior? And how does this change risk? In a post-event review, it is important to study these interactions. Table 2 below provides an example of applying these frameworks to the flooding caused by Cyclone Idai in Southeastern Africa in 2019.

Table 2. Applying the Systems, Agents, Institutions and 5Cs frameworks to Cyclone Idai (2019) in Malawi

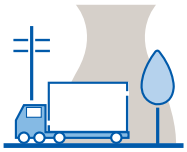
	Systems	Agents	Institutions
Natural Capital	Degraded uplands exacerbate runoff and flash-flooding downstream. Surface water and shallow groundwater quality is dangerously poor. Available natural capital is oversubscribed and increasingly poorly supports livelihoods.	Extensive human habitation on floodplains. Heavy use of land for agriculture, grazing, and fuel.	Very little policy in place regarding environmental conservation. No control over harvesting of wood for charcoal or density of grazing animals.
Physical Capital	Rural housing is primarily mud and thatch and readily failed in the face of 5 days of rain and wind leaving people without shelter and resulting in lost assets. Storm/flood shelters were available, but were only used by those who are regularly impacted by flooding.	Homes are being built less robustly due to overuse/ insufficient availability of thatch. The most vulnerable rural communities are heavily dependent on humanitarian aid and development funding to support the installation of boreholes and development of alternative agricultural practices.	Some NGOs have created models for more robust construction using locally available materials, but that information has not been widely disseminated. Resettlement of communities living in high hazard areas is being considered by the government
Financial Capital	Rains and floodwaters ruined the harvest; impacted households lost stored food, seed and poultry. Cooking equipment was lost due to winds and collapsed structures.	Most rural households have little or no savings available to build more robustly or to self-fund recovery.	Centralized government funding limits ability of District Officers to act. Food aid and cash-for-work transfers are standard NGO and government disaster response.
Social Capital	The majority of the populations of all three countries are subsistence farmers, locked into generational cycles of poverty. The consequences of climate change and the impacts of the cyclones make it more difficult to break free of these cycles and have a significant impact on people's capacity to adapt and recover, for example discussing where future safe land for livelihoods and adequate living can be located – a difficult discussion of "resettlement".	Pre-positioning or response supplies by the government based on the storm forecasts and emergent rescuers in boats were both instrumental in saving lives.	In vulnerable Malawi communities, there is strong culture of aid dependency.
Human Capital	NGOs are the primary actors in disaster risk reduction in Malawi. Early warning systems, from international/national forecasts all the way down to community dissemination, exist and are functional.	People expect early warnings and know how to respond when they receive them. However, the rainfall coupled with wind in Idai were new and people were unclear on what the impacts would be/who would be affected.	Disaster management is centrally coordinated through DoDMA; DoDMA is a strong presence in most of the country. However, there is limited coordination between DoDMA and other departments like the Environmental Department. NGOs that are not directly engaged around weather/climate don't receive, use or disseminate forecasts or early warnings.

Table 2b. Applying the Systems, Agents, Institutions and 5Cs frameworks to COVID-19

	Systems	Agents	Institutions
Natural Capital	• Space (or lack thereof) for physical exercise. • Reduction of limited open space for temporary hospitals (i.e. makeshift hospital in Central Park) • Clean air and clean water can contribute to healthier populations. • Air pollution can exacerbate impacts: Improvements in air pollution from factory closures and less commuting. • Wildlife increasing in developed areas due to decreased stress on natural environment	• Overburdening of open spaces/ national parks/ beaches, and stress on employees and systems • Using parks for fitness classes (i.e. yoga), which is atypical for the US. • Flexibly restructuring activities to conduct them outside	• Rules/regulations around using outdoor spaces and physical distancing. Need to rapidly adapt rules and regulations pertaining to access and use.
Physical Capital	Hospital capacity • Limited hospital beds and critical care equipment • Universities/hotels/convention centers used as overflow health facilities Lack of PPE • Can supply chains keep up? Food, water, power, shelter • More load on internet providers; Can supply chains keep up? Chinese suppliers shut down for months with global impacts • No shelter for homeless populations due to stigma around homelessness and physical distancing requirements College & School closures	Hospital capacity • Trained (and healthy) health care workers Food, water, power, shelter • Panic buying and hoarding; Food producers are 'essential', Amazon is 'essential', but inadequate protection is being provided to workers Testing capacity • Slow mobilization of institutions	Lack of PPE • Prioritization, limited stockpiles Potential vaccination & treatments • Requires adequate funding and extensive testing; Requires flexibility re: rules around treatment development and testing • Adequate funding for scientists Testing capacity • Red-tape within FDA/CDC regarding development and approvals
Financial Capital	• Stock market • Economic impacts to industry: travel, airline, small business, retail, hospitality	• Business closures, loss of livelihoods • Employment/ Unemployment	• Stimulus
Social Capital	• Facebook, NextDoor, Zoom, etc.: supports connection between friends and co-workers as well as between strangers. Downside is that these technologies can facilitate the spread of misinformation and conspiracy theories.	• Self organizing to purchase and deliver groceries for vulnerable populations • Lack of trust in federal response, in general greater trust in state and local government • Lack of trust in science	• Physical distancing rules: different impacts on different groups depending on social structure and social norms
Human Capital	• Shift in education practices for teachers, children and systems • Systems and agents; Public communication and education about COVID-19 (public health guidance, stay-at-home orders etc.).	• Trained health workers, Public Health officials, scientists, and local, state, and federal government officials • Impacts of pandemic on health of healthcare providers	

The following characteristics of resilience are useful for parsing out interactions between systems, agents, and institutions within and between the 5 capitals and identifying the successes, failures, and opportunities for action (see Table 3, on page 12):

Table 3. Characteristics of resilience, adapted from Moench et al., 2011

Component	Characteristic	Description	Examples
 **Systems** Infrastructure/ Ecosystems	Flexibility & diversity	The ability to perform essential tasks under a wide range of conditions, and to convert assets or modify structures to introduce new ways of performing essential tasks.	• Food is imported into the city from numerous, diverse national and international locations, so if crops fail in one region, food is still available. • Community flood shelters can be flexibly used during non-flood periods, doubling as clinics or meeting halls.
	Redundancy & modularity	Spare capacity for contingency situations or to accommodate increasing or extreme surges in pressure or demand; multiple pathways and a variety of options for service delivery; and/or interacting components composed of similar parts that can replace each other if one, or even many, fail.	• Multiple roads lead out of the city so that if one roadway is blocked, alternate routes are available. • Water tanker trucks provide modularity: if one truck fails, the system is not seriously affected.
	Robustness & safe failure	Infrastructure is robust to minimize failure, but also designed so that if/when they fail, it is in predictable or planned way that minimizes damage; ability to absorb or respond to sudden shocks or the cumulative effects of slow-onset stress in ways that avoid catastrophic failure.	• Dikes and floodways can channel extreme floods into wetlands or retention zones where they cause minimal damage. • Fuses and breakers in home electrical systems break or fail rather than letting a power surge melt wires or destroy electronics.
 **Agents** People and Organizations	Responsiveness, rapidity & reorganization	Able to organize and re-organize in an opportune fashion; ability to establish function, structure and basic order in a timely manner in response to a disruptive event or organizational failure.	• Utilities release water from a water supply or power generation reservoir in advance of a forecasted typhoon to allow for floodwater storage and avoid catastrophic release. • Disaster risk reduction planning, training and re-structuring for community organizations • Before a large storm or flood forecast, move furniture up to the second floor.
	Relationships	Relationships help build trust between different agents and ensure that they can work collaboratively when the need arises. Relationships can expand the networks of agents and help them access different geographies, types of capital, and so on. Therefore, relationships are the basis over which networks are able to provide physical and emotional support and resources.	• Neighbors help neighbors during and after floods. • Humanitarian organizations leverage their relationships with community-based organizations (e.g., churches, youth centers) to open evacuation centers.
	Resourcefulness	Capacity to identify and anticipate problems; establish priorities, and mobilize resources for action. This includes the capacity to visualize and plan, which may require collaboration. It also includes the ability to access the 5 types of capital, including those of other agents, and resources from systems in order to take action.	• The ability to access credit or insurance to protect against and recover from shocks and to leverage opportunities. • Organizations 'think on their feet' when unexpected failures occur during a disaster. This includes innovating and implementing solutions quickly and effectively.
	Capacity to learn	The ability to learn new information, skills, techniques and behaviors, and to internalize past experiences to avoid repeated failures and innovate to improve performance.	• Formal and informal review of performance of key systems to identify opportunities for improvement. • The ability to understand and implement innovative changes, such as adopting a new housing design, to address recurrent flooding.

Component	Characteristic	Description	Examples
 **Institutions** Laws, Regulations and Cultural Norms	Rights and entitlement	The rights and entitlements to use key resources or access the five capitals; equitable distribution of core system services; etc. Rights and entitlements can enable or constrain responses to disruption and significantly influence the ability to and speed at which recovery unfolds.	• All residents have access to water and water is priced to provide minimum basic needs at a rate that the poorest inhabitants can afford. • Lack of legal standing (e.g., illegal immigration status) can exclude impacted households from accessing post-disaster aid.
	Inclusive decision-making	Decision-making processes, particularly in relation to development and systems management follow widely accepted principles of good governance, chiefly: transparency, accountability and responsiveness.	• Diverse stakeholders have ways to provide meaningful input to decisions.
	Access to information	Private households, businesses and other decision-making agents have timely access to accurate and meaningful information to enable judgments about hazard and vulnerability and hence their risk, and for assessing adaptation options.	• Useful, clearly presented information regarding hazards and possible response options are available to the public through accessible media, such as in newspapers, on the radio or television, and on websites.

Ultimately, recommendations – generated using the Five Capitals and Systems, Agents, and Institutions frameworks – should identify where and how (Tyler & Moench, 2012):

1 Infrastructure and ecosystems can be strengthened. Particularly, where fragility and risk of cascading failure be reduced and/or the provision of services strengthened and made more equitable.

2 Capacities of agents can be built. Capacity to anticipate challenges, proactively identify both challenges and opportunities, and develop adaptive responses should be a primary focus.

3 Institutional factors that constrain effective action or undermine the ability of agents to act can be addressed.

3 Methodological approach

To effectively conduct a PERC, PERC researchers should understand:

1 The conditions that caused the hazard to become a disaster. Here, it is important to remember that while hazards are natural, disasters are not. Disasters result from a combination of natural hazard events occurring, the presence of people and assets in the impact zone of the hazard, and the social, economic, and political vulnerabilities of the people and systems in that area (Blaikie et al, 1994; Oliver-Smith, 2004).

2 The experiences of key players in disaster risk management across scales (i.e., national to local). This allows PERC researchers to build the narrative of what happened and identify challenges and successes.

3 The core systems, agent capacities, and institutions that need to be addressed to reduce fragility and enhance resilience during hazard events.

Post-event reviews can be conducted in any context. To date, we have conducted PERC studies on every continent except Antarctica, ranging from rural and peri-urban communities along the Karnali river in Nepal to informal settlements in Piura, Peru to densely populated urban areas such as Houston, Texas, USA. Key gaps and successes are surprisingly similar across the full range of these contexts (see Section 6). PERC studies can also be conducted in areas where resilience interventions are already underway, and can be integrated with community-based resilience measurement initiatives such as the Zurich Flood Resilience Alliance's Flood Resilience Measurement for Communities (FRMC) framework and tool to further understand resilience and the necessary types and effectiveness of resilience interventions (see Box 2; Zurich Flood Resilience Alliance 2015c).

Box 2. The Flood Resilience Measurement for Communities (FRMC)

The Alliance's Flood Resilience Measurement for Communities framework and associated tool is a community-level tool for measuring flood resilience based on the "5C-4R" framework—the five capitals that sustain and can help to improve community members' wellbeing (physical, financial, human, social and natural capital), and the four separate properties that characterize resilience (robustness, redundancy, resourcefulness, rapidity).

The FRMC can be used to identify where resilience needs to be built, or how resilience interventions 'performed' post-event, and to monitor and evaluate the success of resilience-building initiatives. Users of the FRMC (i.e., community development practitioners, municipal governments, or civil organizations) work with communities to measure each of the capitals as they are present in the community and as they pertain to flood resilience. Each capital is represented by a set of mutually exclusive indicators, referred to as 'sources of resilience', which can be identified in the community pre-hazard and are proxies for resilience.

In total, there are 44 sources of resilience identified in the FRMC framework. These sources provide resilience because they contain one or several inherent characteristics of resilience (see Table 3). Each source of resilience is measured by comparing data from the community with a definition of what that source can look like and assigning the source a numerical score based on the comparison. The resulting semi-quantitative, semi-qualitative scores can be aggregated to measure resilience within that capital or aggregated across all five capitals.

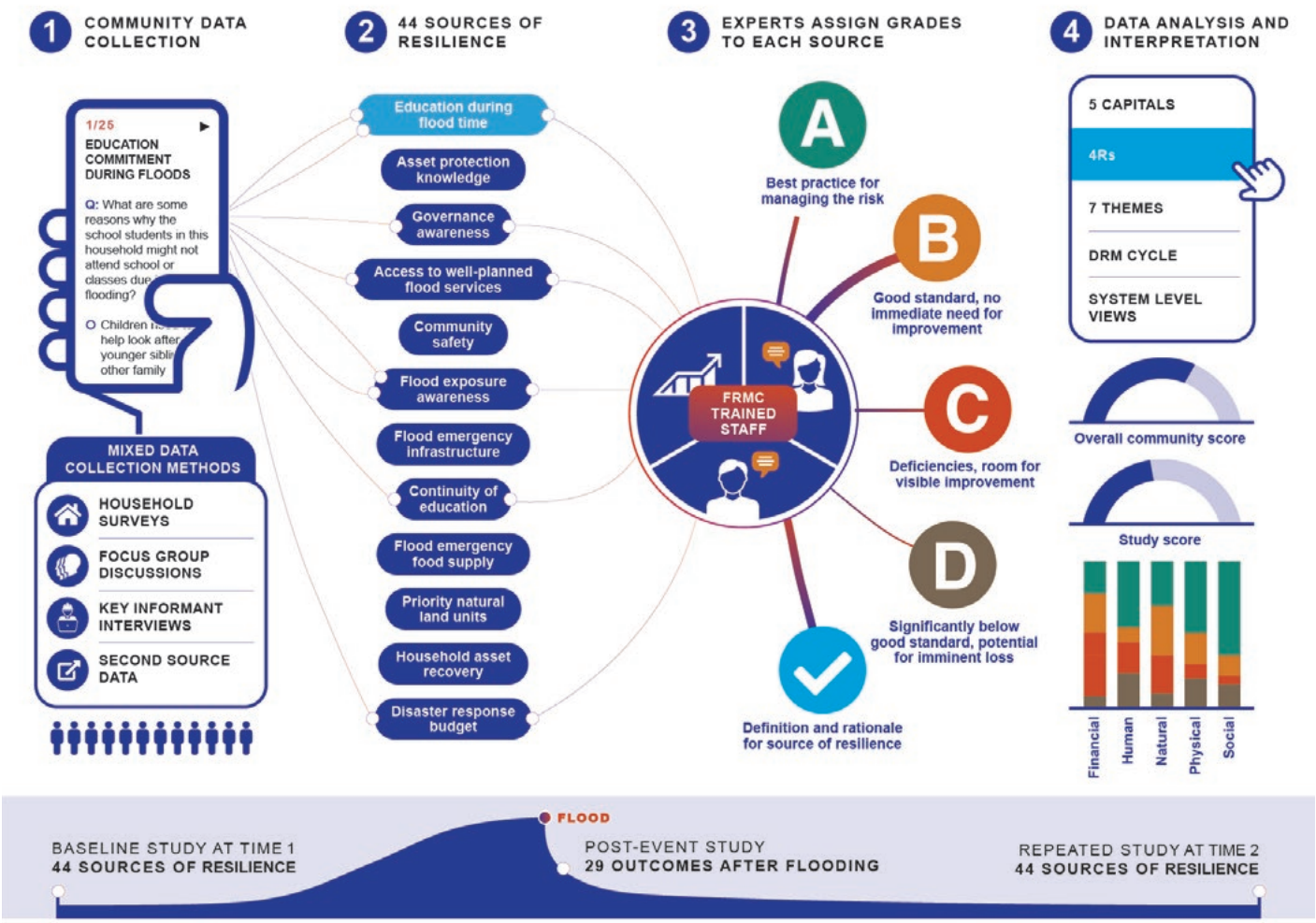
The insight gleaned from evaluating the resilience level of each of the sources and capitals can be used as an entry point for prioritizing interventions carried out as a part of community programs. Furthermore, the FRMC can be used to measure the impact of resilience building interventions by comparing FRMC baseline assessment scores with endline assessment scores. The validation of the sources of resilience measured by the FRMC is currently underway.

To learn more and apply for the use of the FRMC, visit https://floodresilience.net/frmc

How the FRMC fits into PERC

The major differences between the PERC and the FRMC are the scales of focus (i.e., community vs. multi-scale) and the time step (pre- versus post-event). PERC is more individualized and flexible, while the FRMC is standardized. The FRMC is designed to be employed before a flood event to understand ahead of time where resilience needs to be built and to track changes in resilience over time, while PERC is a post-event review. In the case of a flood-prone area, PERC can help deconstruct the wider physical, social, economic, and political drivers behind the flood impacts faced by communities and their resilience (or lack thereof). NGOs, government, and other key players can use the deeper context and the opportunities for action identified by PERC to focus, inform and modify resilience-building interventions at the community-level. If the FRMC, or any other community-based resilience or disaster risk management evaluations, have been undertaken in the PERC study area, the information contained within these would provide useful input into the PERC study, in particular for understanding the pre-event resilience at the community-level.

Figure 2. The Flood Resilience Measurement for Communities (FRMC) process



It is equally important to work with partners that have a range of perspectives. When possible, the PERC team should include people from both social and physical science fields.

3.1 Identifying stakeholders and available information

A PERC study is best conducted in collaboration with local partners (i.e., government agencies, safety-net organizations, NGOs, community leaders) that have been working in the areas in question for an extended time and have an understanding of the local context and the connections needed to collect useful, reliable, and accurate information. It is equally important to work with partners that have a range of perspectives. When possible, the PERC team should include people from both social and physical science fields. This helps ensure that collected information, analysis, and recommendations are generated through a multi-disciplinary lens. When this isn't possible, retain an awareness of where the PERC team lacks expertise and critically evaluate a range of additional sources to understand how that sector influenced the event.

Partners should not have deeply vested interests in the outcome of a PERC study. While many organizations have a stake in the outcome of a PERC, partners must be cognizant and welcoming of the fact that this is an independent study. Even in an unbiased study, findings critical of the status quo need to be used thoughtfully; however, discounting those findings entirely for political or institutional reasons would be unfortunate.

Partnerships should be built strategically to ensure the uptake of PERC recommendations. The nature of the PERC, as independent and neutral, makes implementation challenging as researchers may lack the authority or opportunity to follow-up on recommendations. Particularly for PERC studies that are conducted primarily for research purposes, teaming up early with people and organizations who are interested in using the PERC results should be considered. Conversely, PERC studies done primarily to help focus post-disaster action will ideally also be sent to the Zurich Flood Resilience Alliance so findings can be included on our Knowledge Portal.

3.2 Study timeline

PERCs to date have typically been conducted following the response phase and early in the recovery phase, but not so late that the opportunity to learn from the disaster is lost and/or the next phase of disaster risk management has already begun. In the case of floods in subtropical countries, for example, a PERC study is best conducted before the next monsoon season begins.

If a PERC is conducted too soon after an event (i.e. during the response phase), key actors will be focused on providing critical humanitarian assistance, and will therefore be difficult or impossible to access. Similarly, visiting impacted areas may be impossible, dangerous, or at least insensitive. It will also be difficult to already adequately evaluate what happened and what recovery will look like. Those involved will also have less to say; impacted peoples and key disaster risk management actors need time to overcome the initial shock and process what has happened.

However, if the PERC is conducted too late, memory may fade and information may be lost. What constitutes 'too late' will depend in part on the scale and type of event, and in part on what you want to learn from it. The Fort McMurray Wildfire PERC (number 15 in Table 1) was conducted several years after the event and produced important learning. However, the scale and destructiveness of the event seared it into memory; it was the largest wildfire evacuation ever in Alberta, and one of the most destructive and expensive fires in Canadian history. The Peru pre-event El Niño study (number 11 in Table 1) looked back at previous El Niño events in Peru but did not rely on a current or even recent event; highly destructive El Niño-associated floods in Peru occur roughly decadally and such an event hadn't been experienced in years at the time of the study.

PERCs generally take three to six months from the initial planning to the publication of the final report. This timeline is dependent on the size and scope of the study and the local situation. More or less detailed PERC studies, or those conducted for larger or smaller events, might require different timeframes.

The PERC can be adapted to address other scopes, foci, scales, and timeframes if needed; indeed, this flexibility is one of the strengths of the methodology. For example: a retrospective PERC could be conducted using remotely-sourced materials and interviews; a mini-PERC might be used to look at smaller scales or answer specific questions; a multi-event, historical PERC could be conducted to look at a series of similar historic disaster events to identify places where learning is, or is not, occurring over time; and a 'pre-event', scenarios-based PERC could be conducted to identify potential points of failure and fragility that can be addressed to reduce losses during a future event (see Box 3). The pre-event PERC conducted in Peru in anticipation of a severe El Niño is an example of this last type. While the specifics of the information researchers might look for, the way interviewees are selected, and the types of questions asked will vary based on the context and goals, the basic PERC approach remains the same across all these applications.

Box 3. Scenarios approach for projecting future risk

The PERC approach can be integrated with forward-looking scenario analysis to identify fragilities and vulnerabilities that, left unaddressed, could lead to future losses and damages. Scenarios link top down scientific information (e.g. generated via climate, economic, or planning models) with bottom up narratives (e.g. generated via participatory processes) to project how shocks could manifest given a particular trajectory of development, urbanization, growth, and shock intensity. Scenario analysis has been widely used for global, collective problems associated with high uncertainty (e.g. climate change) as well as applied in local contexts to explore solutions to local problems (e.g. siting of waste dumps).

Developing future scenarios involves asking the following questions:

1 How could the study location change due to physical, economic and social change processes (e.g. climate change, urbanization, population growth, migration) over time?
   – How would this affect exposure?
   – How would this affect vulnerability?

2 Is the hazard of interest changing? How will this change affect issues discussed in question 1?

3 How are the change processes discussed in questions 1 and 2 likely to exacerbate or reduce the risk posed by hazard events?

For example, in a robust-information context where climate change projections are readily available, projections could be used to explore how changes in sea level rise or flood frequency would influence the prioritization of risk reduction activities. Identifying the economic and social change processes in this example will still require conducting interviews and desk-based reviews. In limited-information contexts, where climate projections may not be available or there are significant gaps and inaccuracies in existing records, PERC researchers would have to rely more heavily on interviews and participatory processes to identify future scenarios.

Once future scenarios are identified, researchers then explore the implications of those change processes, in terms of both how risk might be increased and how that risk could be alleviated. This requires an understanding of gaps in the existing system, ongoing dialogues about how to address risk, what DRM strategies are currently being implemented or will be implemented in the future, and what potential issues still remain.

One way of organizing thinking around identifying future scenarios is along the 5 capitals, which determine exposure and vulnerability:

Capital	Past (e.g. 20 years ago)	Today	Future (e.g. 20 years from now)
Natural			
Social			
Human			
Physical			
Financial			

For each of the capitals, think through what life was, is, and may be like within each of the capitals due to the key change processes identified. Then, think through how a shock may disrupt each of the capitals, and what impact that could have on what you have described. This will help identify and prioritize how to best address risk and build resilience in the study location.

3.3 Desk review

The first step to a PERC is to conduct a desk review. A desk review involves looking at newspaper articles, opinion pieces, peer-review articles, working papers, and reports about the disaster event itself as well as further background material. In the desk review, explore not just the current event, but also previous, similar events, as well as the prevailing risk context, the physical landscape, the vulnerability context, the institutional landscape, and so on. This research provides necessary context and will help direct and focus fieldwork. It will also help to identify key players and potential interviewees and to find on-the-ground groups or key actors to collaborate with for the PERC.

An independent and objective PERC necessitates an honest scoping of the literature that includes opposing viewpoints rather than specifically chosen sources supporting one particular position. Secondary literature (for example, sources used during the desk review) must be drawn on throughout the study, particularly when judgements are made. Tying judgements and conclusions back to specific sources and/or interviews as you do your analysis will significantly strengthen your conclusions and result in more compelling study results.

3.4 Understanding physical conditions

An initial understanding of the physical conditions on the ground will come from the background literature review. This should be expanded through an analysis of the physical drivers of the disaster event. Much of the more detailed information will come from interviews, as described in the next section. If the team does not have a physical scientist (depending on the hazard, a hydrologist, geologist, etc.), then this information can be derived through secondary literature and through interviews with the appropriate experts.

In exploring event details, consider what the event was, why it occurred, how it unfolded, etc. In the case of a flood, this would include hydro-meteorological analysis of the event—was it due to intense rainfall, sustained rainfall, high tide, dam or embankment break, etc. This analysis should be compared back to previous events—for example, was this the expected flood pattern or was this an unanticipated or very different type of event compared to previous floods?

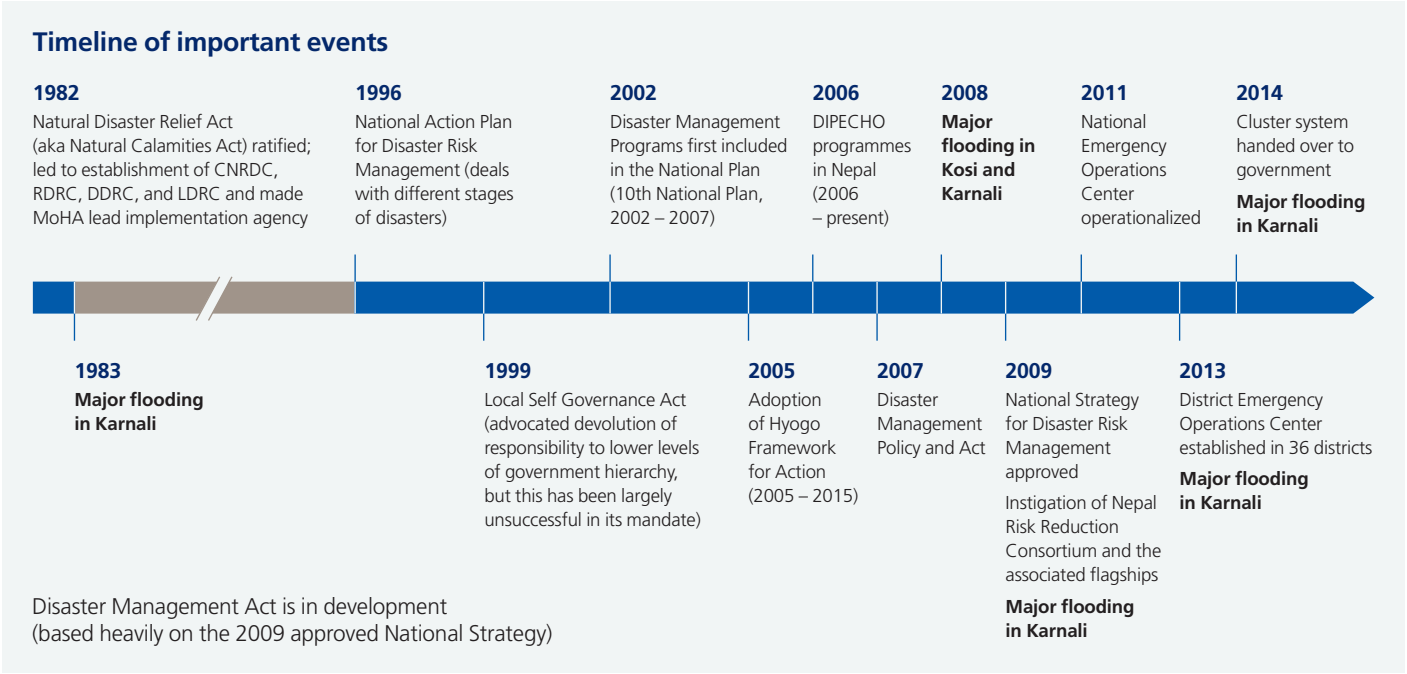
If possible, calculate or estimate the return period of the event to provide a sense of the frequency or rarity of the event. Identify and explore evidence that these events are occurring more frequently or with greater magnitude than in the past. In particular, give thought to whether perceived increase in the frequency and/or magnitude of events stems from changes in the hazard (e.g., heavier rainfalls), changes in exposure (e.g., more people living in the floodplain, infrastructure changing flood water flow paths, etc.), and/or changes in vulnerability of the people and assets in at-risk areas (e.g., because of population increases and associated pressure on locally-available building material, home construction techniques are less robust than they used to be) or purely from improved observation and measurement techniques (e.g. the occurrence of lightning strikes or tornadoes).

In identifying the severity of the event, note whether the event was of a severity that was planned for or whether it was beyond the planned severity. For example, in many parts of the world, infrastructure is designed to handle 1-in-20 to 1-in-100 year floods. Similarly, first responders typically prepare to provide emergency housing for up to a certain number of people of a certain demographic. How did the event compare relative to local planning standards?

If a component of the event was due to physical structure failure (i.e. a dam or levee broke), include an exploration of that failure. Why did the physical structure fail? Was this anticipated or unanticipated? If anticipated, were damages greater or less than expected? If, for example, a levee failed, why was the levee not strong enough for this size event? Sometime events are truly just bigger than we plan for; more often, we fail to plan realistically, fail to maintain our infrastructure, and/or fail to set up regulatory environments to support our infrastructure to work the way it was intended to work. All of these issues should be explored as you look at what happened.

The analysis of the physical events underlying the disaster helps set the stage for what unfolded. Most of our PERC studies have been of 'unprecedented' events. A few of them have included truly unprecedented elements, but most of them highlight known gaps where something failed with catastrophic impacts. A familiarity with the scale and intensity of the event and how it aligns with historical events (see Figure 3 for an example timeline) both at the same location and within the same country or region, will strongly inform the interviews.

Figure 3. Example timeline of past floods and major disaster-related institutional events in Nepal



Increasingly, an element of this analysis for any natural hazard event needs to include an evaluation of the role played by climate change. It is beyond the scope of a PERC to attempt a climate change attribution exercise, and for the most part research studies linking the scale or intensity of a particular hazard event to climate change tend to lag the PERC in timing. Consequently, for most of our PERCs, we note if there is an association — for example, Hurricane Harvey resulted in the third 500-year flood in three years, hurricane intensity and moisture content is known to increase with sea surface temperature, and summer sea surface temperatures off the Houston coast are now averaging 4°F higher than they were 60 years ago when the flood maps were drawn. This would suggest that Houston should be prepared for more events like Hurricane Harvey. It was not, perhaps, as 'unprecedented' as one might hope. Similarly, the Tasmania and California wildfire PERCs found strong evidence that climate change is leading to increased dryness during fire season, which in turn is exacerbating the potential for ignition and contributing to increased extent of burned areas when fires are ignited.

Box 4. Applying the PERC to a non-flood hazard

Though initially developed for use in studying flood hazards, the PERC is rooted in an understanding of why a hazard became a disaster and applies a vulnerability and disaster risk management lens to generate recommendations. As a result, the PERC can be adapted to a wide range of hazards, for example in examining the wildfires in 2018 & 2019 in California, USA; the Fort McMurray Fire in Canada, and the Tasmania fires in Australia. Other hazards can be studied using the same systematic process:

- Desk reviews and interviews will need to be conducted with a broad pool of stakeholders, including key disaster risk management organizations and officials, government, critical service providers, humanitarian aid and safety-net personnel, and community-based organizations and committees, as well as community members and small business owners.
- An analysis of broader systemic processes should be used to build an understanding of the dynamics of the hazard in general and the study event in particular.
- Exploration of broader demographic and economic patterns will help uncover development trends that may have exacerbated exposure or vulnerability.
- Past events should be used to inform understanding of current events and broader patterns and trends, including whether the hazard event is changing in intensity or frequency, is completely new to this geography, etc. The goal is to understand whether perceptions of intensity or frequency are the result of changes in exposure, vulnerability, or in the hazard itself.

More significant modification to the methodology may be needed for a very different event type, for example for a slow-onset event like a long-term drought as opposed to the fast-onset nature of floods and wildfires. Similarly, very different hazard types may have very different entry points for building resilience and recommendations may be more relevant for very different audiences or levels. The following points need to be considered when applying a PERC to a non-flood event:

Timing: Usually PERCs are conducted after the response phase and during the recovery when there is more time for introspection and learning. This will differ depending on the hazard and the context. Applying the PERC to a drought, for example, might mean doing a "mid-event" review rather than a "post-event" review if a particularly long, multi-year drought is being studied.

Experts: Reach out to country and hazard-specific experts at the beginning of the PERC to provide guidance and insight for setting up, conducting and writing up the study.

Flexibility: While desk research provides insight into where researchers should focus their interviews and field research, information provided once in the field may require a shift in location or focus. Flexibility is an element of any PERC, but greater flexibility may be required in some events than in others. During the California Wildfires PERC, for example, it immediately became clear that finding community members, local government, and small businesses to talk with following the 2018 Camp Fire in Paradise, California would be extremely difficult as nearly the entire town had been displaced due to the wildfire. These types of situations require researchers to adapt plans and timeframes.

Stakeholders: Key institutions involved in response and recovery and key sectors and populations impacted will most likely differ depending on the hazard and context. For example, floodplain managers are key informants for a flood, wildland management specialists are key informants for wildfire, and the Office of Emergency Management will probably be involved in both events. A comprehensive desk review of the hazard and context, followed by soliciting input from experts, will help researchers begin to expand their knowledge of key stakeholders.

In sum, modifying the PERC approach for other hazards isn't hard, but it does require time, thought, and a systematic approach to do it well.

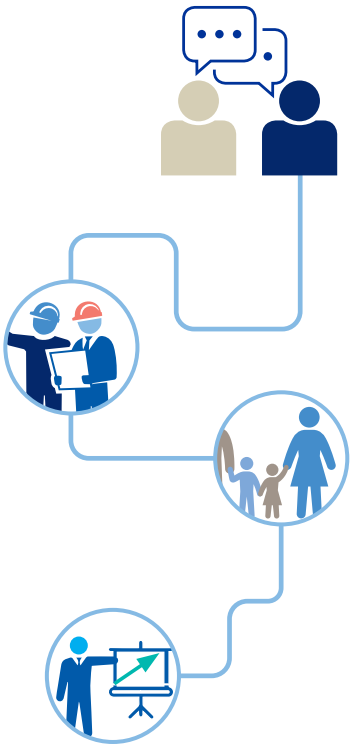
3.5 Fieldwork

The heart of the PERC is the fieldwork. Visiting the affected areas and speaking with those involved in the disaster provides a level of context, information, and understanding that would be otherwise near-impossible to obtain. It is during fieldwork that the majority of questions will be asked and answered. As mentioned earlier, the fieldwork is best done in collaboration with at least one local partner. Even local partners, talking to existing contacts, will learn new things over the course of a PERC.

In the field, the main methods for information collection are personal observation and interviews. Personal observation quite simply consists of documenting the thoughts, comments, questions and observations of the PERC team – it is part of the "forensic" aspect of the PERC, collecting and reviewing the evidence and trying to put them in the right place. It also helps in building and corroborating or rejecting hypotheses of what happened and why, which will guide your questions and preparations for interviews. This section will focus more on how to conduct interviews.

PERC interviews are conducted using a semi-structured interview process. Unlike formal interviews, which follow a rigid format of set questions, semi-structured interviews focus on specific themes but cover them in a

the loose format means that interviewees can provide valuable information and stories that were not anticipated by the PERC team



conversational style. The loose format means that interviewees can provide valuable information and stories that were not anticipated by the PERC team. It also allows the interviewer to deviate from the plan in order to explore more pertinent topics with the interviewee as they arise.

Initial interviewees are identified during the desk research. Once in the field, a snowball sampling methodology is used where current interviewees identify additional potential interviewees. Not all of these recommendations will be followed up on; ultimately, the goal is to engage with a broad range of stakeholders from different sectors and levels of action (i.e., household to national) with different expertise and vested interests.

The interviewees provide the information needed to structure the institutional landscape map (see Section 3.6 for more details), the narrative of what happened before, during, and after the event in question, and the socio-economic and socio-political conditions that led to vulnerability.

Who to interview:

1 Key people and organizations in the disaster risk reduction, preparedness, response, and recovery processes across scales (including local, district, provincial, national, and regional if applicable), including emergency response personnel, key humanitarian aid agencies, public, private and non-profit groups working on preparedness, government officials, engineers building key disaster protection systems, groups active in recovery, and loan providers among others.

2 Decision-makers and planners whose work affects risk, such as planning authorities, municipal authorities or local governments, community representative groups, local and international NGOs working in the affected areas.

3 Those who are responsible for providing key services such as electricity, water treatment, solid waste management, transportation, communications.

4 Communities, households and businesses (including industry associations) that were impacted by the event, and possibly those who weren't if there is reason to believe lack of impacts were due to preparedness or mitigation actions that would provide a valuable story.

5 Local/national academics or experts who may have insight into any aspect of why the event unfolded as it did. This could include people with insight into the contexts of vulnerability, historical and current land-use, enforcement, physical science, political context, and so on.

6 The initial group of interviewees should be determined with local partner(s) and informed by the desk review; this may involve people and groups that the PERC team knows personally or have worked with in the past. Who else to interview will depend on the questions and remaining gaps. Stop interviewing once the information provided feels repetitive and does not provide new, important information.

During each interview, it is important to:

1 Explain the purpose of the interview and the study, emphasizing that PERC is designed to be an independent process for learning. The PERC is not about assigning blame or reviewing the performance of any individual or institution. Rather, it is focused on finding insights that will support building a systemic picture of the event, highlighting successes that prevented greater damage, and identifying particular opportunities for building resilience moving forward.

2 Before starting the interview, obtain consent for conducting the interview and for using the interviewee's name/other identifiers in the report. If interviewees do not consent to using their name/other identifiers in the report, keep their identity anonymous in the report, including by removing identifying details in their account. Commit to sharing the draft report with the interviewee for review purposes and the final report for their future reference. (Note: Zurich Flood Resilience Alliance reports typically keep interviewees anonymous with the exception of particularly compelling stories or quotes, for which we obtain explicit permission and have those quoted approve of what we have written/quoted.)

3 Conduct the interview in the language that the interviewee is most comfortable speaking. If no one on the PERC team speaks the local language, hire or include in the PERC team an independent and impartial translator who is familiar with the disasters field, the types of questions being asked, and the types of information being sought. While partner organizations may be a useful translator resource, remember that staff of partner organizations may not be as independent as other, external translators.

4 Ask appropriate questions. Box 5 below provides a list of questions that can be used to help guide discussion. Whether and how these questions are asked will depend on the context (i.e., who is being interviewed and the type of information already collected).

5 Think outside the boundaries of the guideline questions to obtain the information needed:

   a **Probe for more detail** – ask who, what, when, where, why and how. (e.g. If someone relays that they have been implementing preparedness activities, ask, "what kinds of preparedness activities have you been implementing? Have they been successful? Why or why not?")

   b **Compare and contrast** – Prompt the interviewee to think about similarities and differences between things—especially before and after key events. ("How did you change your practices after the 2006 floods? How did it help during the most recent floods?")

   c **Imagine alternate futures** – Ask questions that invite the interviewee to imagine 'what if' in an alternate reality. ("What would you have done if you had received a flood warning a day in advance?")

6 Be respectful of time. PERC interviews conducted to date typically ask interviewees for an hour of their time and bring the interview to a close at the end of that hour. If the interviewee is particularly informative you can ask if they would be willing to be available for follow-up questions or extend the interview for an additional set period of time (e.g. 'I know we've been talking for an hour, but I'd like to hear the rest of your story. Can we continue for an additional 15 minutes?')

7 Think critically about the information that is being provided. Is it accurate? Is the information provided blurring the facts? Does it feel particularly one-sided or lacking critical detail? Does this information give rise to other questions that the interviewee may not be able to answer? Write down these thoughts immediately following the interview.

Make sure to ask the interviewee whom else they think the PERC team should talk to, for contact information, and possibly for an introduction to those people. During the site visits, there will also be opportunities to conduct informal interviews, perhaps with directly impacted communities, businesses, and households, indirectly impacted businesses (e.g., businesses impacted by loss of customer base), and so on. Informal interviews, because they take place within the context of where people live and experience their daily lives, can provide a wealth of information and can serve to answer immediate questions at a particular location. The protocols regarding permissions should also be observed for informal interviews.

Box 5. Guiding interview questions

Guiding questions for interviews with key disaster risk management, government, humanitarian aid and safety-net personnel, and community-based organizations and committees:

- What is/was your role with regards to the event—what establishment or group are you part of, and what is that group's specialization with regards to the disaster?
- What was the situation in the area before the event in terms of trends in people and assets?
- What, if any, risk reduction activities were in place prior to the event? (For example, reforestation schemes, embankment walls.) What was the status of those and why? (For example, community levees were poorly maintained, people felt a new government levee would provide enough protection and local levees wouldn't be needed.)
- What, if any, preparedness actions were taking place? (For example, shelter building, emergency drills, first aid training.)
- What happened during the event? Was this event different from past disasters of this type? Why?
- What was the extent of the loss of life and damage to assets? Which groups were most affected?
- What did the interviewees/their organizations do before/during/after the event (depending on whether they/their organizations are involved in preparedness/risk reduction, response, and/or recovery)? Have past events influenced their actions and capacities? How?
- Were their actions successful? Did they achieve what they set out to achieve? Or were there limitations/obstacles that prevented or inhibited them from acting effectively?
- What have they learned from the event in question? What would they like to see in terms of preventing future disasters? What can they do better and how can they do it better in future, similar situations?

Guiding questions for interviews with local groups (e.g., Community organizations, community disaster committees) and impacted communities, households and businesses:

- What happened during the event?
- How were you affected during this event? And why? Was this event different from past, similar disasters? How/why?
- Was there an early warning system? What is it? Did it work? Why/why not?
- Have you implemented any strategies to reduce the risks that such an event poses? What kinds of strategies? Have you faced obstacles/limitations in trying to implement risk reduction/preparedness strategies? Were the implemented strategies effective during the event? Why or why not?
- What has been your experience with external humanitarian aid efforts? Which groups of people benefited, or not?
- How is recovery progressing? How is recovery being financed? Who is getting recovery financing and who is not?

3.6 Institutional landscape map

The institutional landscape map, although an optional undertaking, is a useful visual for:

1 Understanding the institutional, political and civil system in which disaster risk management takes place, and for visualizing the system boundaries and connections.

2 Identifying key interviewees.

3 Showing key actors involved in the disaster risk management system. This includes actors across scales (national, provincial, district, local) that are involved in planning, implementation, monitoring, evaluation, etc.

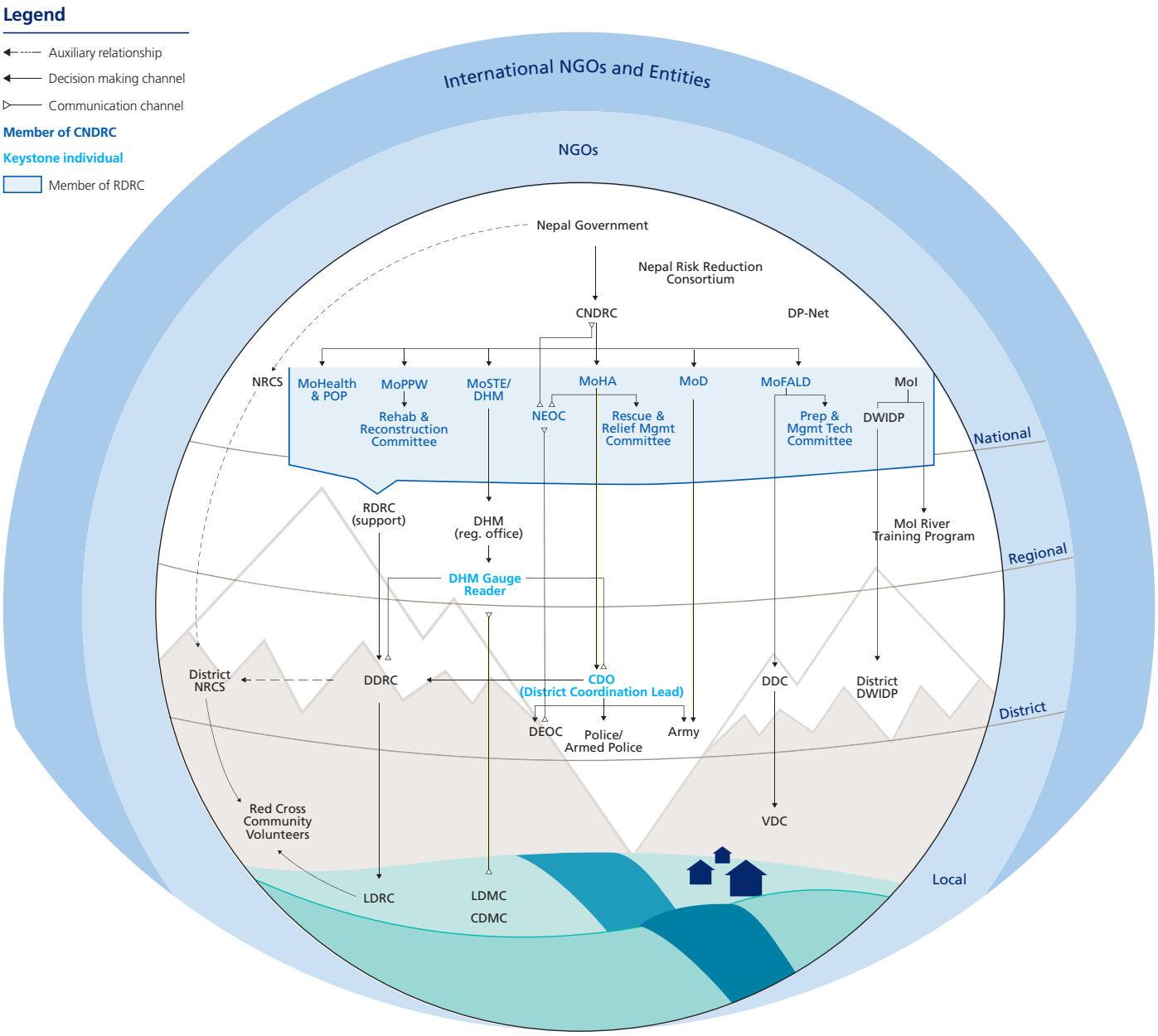
4 Showing key decision-making and communication channels and structures.

5 Showing where there are bottlenecks in the system or where the system failed. For example, identifying that the whole response system is at risk of collapse if one person/agency is not able to perform.

Creating the institutional landscape map is a process that begins during the desk review and goes through the interview phase. The creation of the map is supported by the identification of interviewees using the snowball sampling methodology, as interviewees largely represent the key actors involved in the disaster risk management system. Gaps in the map likely indicate that more interviews are needed to understand how that part of the disaster risk management cycle functions and point to the types of interviewees needed to clarify that information. It is possible to complete an institutional landscape map once you collect enough information from and about key actors, occurrences and experiences before, during, and after the event. However, it can be difficult to access all the information needed to complete such a map due to social, institutional, and political constraints. Gaps that cannot be filled should be mentioned in the PERC analysis.

Disaster risk management practitioners should be able to look at the map and identify agencies/groups that they need to work with for specific interventions based on the recommendations made in the PERC. This may include agencies/groups they need to partner with or build the capacities of. Figure 4 provides an example of an institutional landscape map that was built as an info-graphic in Adobe Illustrator. A much simpler figure in Word, PowerPoint, or other available software could be used to convey the same information.

Figure 4. Disaster institutional landscape map of Nepal (Michelle Fox, ISET-International)



4 Putting it all together

4.1 Analysis

After desk research and fieldwork, the next step in the process is to organize and analyze the information that has been collected. The report structure in Table 4, below, provides an example for organizing PERC data and building the narrative. The PERC report structure is the framework for operationalizing the PERC. Whether or not you choose to produce a final report, it is important to structure the PERC analysis in this format. The report structure reinforces the information that needs to be collected, the types of questions that should be asked in analyzing that information, and how the results can be organized and presented for different audiences. This structure is intended to be flexible, as different contexts and needs may necessitate different kinds of information.

Table 4. Suggested structure of a PERC report

Section	Contents
Executive summary	Report summary with key findings and key recommendations
Introduction	Goals and objectives of the study • Why is this study important? • Why is this event, in particular, being studied? Short overview of event (i.e., duration, location, damages/losses) Short overview of geography of area and the hazard-scape Study methodology Overview of report structure **Key Figures**: Map of study location
Section I: The Physical Context	The history of this type of event in the country/region/location, including changes in frequency and severity over a relevant time horizon, e.g. the last two decades. How this specific event physically manifested (i.e., in the case of floods, this would involve hydrological and meteorological analyses) and which determinants, including but not limited to climate change effects, can be attributed to this event. How this event compares to previous events in the country/region/location An estimate of how future scenarios may play out. **Key Figures**: Further maps of study location, timeline showing past disasters and major disaster-related institutional events (i.e., the passing of key acts/policies, formation of key government groups; see Appendix 1 for an example)
Section II: Socio-Economic Disaster Landscape	Risk and vulnerability • How has exposure to this type of event changed in the last two decades? Has there been a build-up of assets in this at-risk area? • Which groups of people, services, and functions are vulnerable during this type of event? • What underlying factors give rise to that vulnerability? Constraints to reducing risk and vulnerability • What conditions are maintaining vulnerability and constraining adaptation and resilience? Prospective and corrective risk reduction and preparedness • Has there been attention or action relating to the build-up or reduction of assets in at-risk areas? • What are the socio-economic drivers of trends in the magnitude and type of assets in at-risk areas? • What types of regulations exist to avoid the build-up of more exposure and/or vulnerability? • What types of physical protection structures (grey or green) exist? Have they worked in the past? • How did individuals, households, NGOs, government, and other actors prepare and respond in previous events and prepare before this event? • Have these actions and/or capacities exacerbated or reduced vulnerability to this particular hazard? **Key figures**: Institutional landscape map showing the key actors involved in prospective risk reduction, corrective risk reduction, preparedness, response and recovery, and the decision-making and communication channels (See Figure 3).

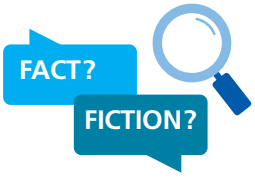
Section	Contents
Section III: What Happened?	Observations and factual information regarding the event; this section should not be mixed with interpretation or recommendations • What happened immediately after people realized an event had struck? (Early warnings? Evacuations? Protection of important assets?) • What were the impacts of the event? (This will be dependent on the time-frame you're looking at and the context within which you are working.) • How did physical protection structures perform? • What kinds of damages and losses did places experience? • What were the indirect impacts? **Response** • How did agents respond? (Rescue, evacuations, relief distribution) • What enabled and constrained response? How did agents work around constraints? • Were there cascading failures? • Who ultimately benefited from response activities? Did everyone who needed help receive help? **Recovery** • What recovery actions are being taken at the household and community levels and by government and organizations at local and higher levels? • Will these actions reduce long-term impacts? • What is enabling and constraining recovery? • Who is benefiting from recovery mechanisms? Is everyone who needs help receiving help? • What are the long-term impacts of the event, particularly for the most vulnerable groups in society? • Is reconstruction being undertaken in a way that avoids the rebuilding of the same risk? What is facilitating or constraining this? **Learning** • Who is learning from the event? • How is that learning being accomplished? • Is that learning being incorporated in ways that will improve future outcomes?
Section IV: Key Insights	What were successes in prospective risk reduction, corrective risk reduction, preparedness, response, and recovery? What are the drivers of these successes? What were critical gaps in prospective risk reduction, corrective risk reduction, preparedness, response and recovery? What are the drivers of these gaps?

Section	Contents
Section V: Recommendations	Recommendations and opportunities for action • These should be actionable, feasible, equitable and just. • They should also be realistic given the social, political, geographical, and economic context. • Particular attention should be paid to the needs and perspective of the most marginalized and vulnerable groups in society. Focus not only on the things that went wrong, but also on strengthening things that worked well. Emphasize single points of failure or bottlenecks where small changes to strengthen systems could have substantial impact. Recommendations should avoid the rebuilding of risk into the system. Recommendations can consolidate patterns of items or elements repeated across scales that were identified during the PERC; they can also summarize patterns seen in this and prior PERC studies that together should be considered going forward.
Conclusions	Concluding statements Could include the national, regional, and/or global relevance of the study
References	If you refer to other documents or printed sources in your PERC, provide a list of those documents and sources, referenced in a format that will make them easy for other users to locate.

The 'What Happened' section provides the detail of exactly what happened during the response and recovery phases–this is not an analysis-heavy section. Rather, the goal here is to provide the facts of what happened during and after the event in a compelling manner. This bird's eye view of the event sets the stage for deeper exploration into the 'Physical Context', 'Socio-economic Disaster Landscape', and 'Key Insights'.

The 'Physical Context', 'Socio-economic Disaster Landscape', and 'Key Insights' sections are analysis-heavy and identify larger trends and patterns contributing to risk and vulnerability, but also resilience and impacts avoided. The 'Physical Context' and 'Socio-Economic Disaster Landscape' sections should bring out the underlying physical conditions that caused the event to manifest in the way it did and the socio-economic/socio-political conditions that led to vulnerability. When considering vulnerability, consider what kinds of capitals people need to prepare for, cope with, and recover from that particular type and severity of event, whether or not they have access to those capitals, and why they do or don't have access to those capitals.

The 'Key Insights' section presents the lessons learned and critical gaps. When analyzing the data, look for the characteristics of resilience identified in Table 2. Were core systems flexible and redundant? Were agents able to draw on their capitals to be resourceful and responsive? Did legal and social norms enable equitable, efficient, and effective response and recovery? Have people and organizations learned from past events and are people and organizations learning from this event? What are the prevalent systemic issues inhibiting disaster resilience in the disaster risk management



It is essential to look at the data critically. Do not accept everything that interviewees and secondary sources present as fact.

system? These trends and patterns should be grounded in examples from the 'What Happened' section; everything you write must be justifiable.

It is essential to look at the data critically. Do not accept everything that interviewees and secondary sources present as fact. People may have different yet equally valid interpretations of the disaster or how the system works. Equally, don't feel required to pick one position; objectively presenting alternative views on contentious issues can help provide depth and nuance to the report. PERC interviewees are not always fully transparent, and secondary sources are often biased, but this does doesn't mean the information they provide is useless. Read between the lines. Did an interviewee claim something and then contradict him or herself? Were they unable to answer a question that they should know the answer to? Did they deflect your questions or answer a question that was different from what was posed? All of these issues may provide useful information about the issues within an organization or components of the disaster risk management system. This will and should also lead to discussions within the PERC team during the field work and analysis phases – did this answer the questions? Why is there this inconsistency? How can be provide a balanced picture of this situation? This is a useful reflection and should be part of the analysis.

4.2 Developing recommendations

The 'Recommendations' section should reflect key insights and identify actionable opportunities. 'Actionable' is particularly important. For example, there is no point in making a recommendation along the lines of "the governance system needs to completely change". It is more effective to make recommendations that are mindful of existing, deep-set constraints. At the same time, the goal is not to design specific interventions; rarely will a PERC team have the expertise and contextual insight required to make such recommendations. Rather, recommendations should focus on wider trends and critical gaps identified in the 'Key Insights' section and provide the justification for local actors and organizations to take action in these areas.

Recommendations should be constructed such that owners who can potentially operationalize the recommendations are identifiable (but not specifically identified in the study by name or organization as to not undermine the trust-based approach of PERC). The exception to these guidelines is if the PERC is conducted in close collaboration with an implementing organization or agency, in which case recommendations can be more specific and targeted as long as they can be directly drawn from and supported by PERC information.

Finally, the Recommendations section should read as a standalone section so that those who do not read the full report will be able to make sense of the recommendations.

5 Dissemination and outreach

PERC database learnings are searchable and can be shared actively and widely amongst global stakeholders.

The full report as described in Section 4 above is how we recommend the PERC analysis be conducted and the questions that should be explored and answered. However, a physical report is only one way to bring PERC research into a structured and credible form. PERC "products" can take many different forms depending on the intended use and the audience(s), including but not limited to individual or group meetings to share learning, topical policy briefs, focused reports for specific audiences, blogs, articles, opinion pieces, or dynamic assets such as podcasts or videos (see Box 6).

Whatever form your PERC products take, make sure they are streamlined and focused. Tailor them for the intended audience, including producing them in the local language, and make sure what is said is justifiable and grounded in the PERC data. A key part of validating study findings is sharing draft materials with interviewees as a 'sense check' before they are finalized to help identify critical errors or gaps.

The PERC is made freely available with the understanding that PERC products developed using this approach will be made freely available on author and partner organization(s) websites and distributed electronically or in paper-format as appropriate to all involved organizations and individuals, in particular to all interviewees. In addition, a distribution or promotional strategy could be devised with partner organization(s) to disseminate study findings and associated products widely. This could include a media release with high level findings distributed to local and national news outlets, a workshop where findings are presented and discussed in more detail with the local community, or other activities such as a stakeholder roundtable, a newspaper opinion piece, etc.

As a condition of utilizing the PERC approach presented here, we remind that PERC studies are not meant to be individual, isolated event reports, but are part of an overall initiative to collect and share learnings. The Zurich Flood Resilience Alliance has built a central knowledge repository (https://floodresilience.net), including a central PERC database, and suggest that all PERC reports are uploaded to this database. Database learnings are searchable and can be shared actively and widely amongst global stakeholders who are grappling with building disaster resilience in their respective locales. We believe this will contribute to a powerful tool for global development practitioners. Please contact info@floodresilience.net for support.

Box 6. Examples of PERC products

Different types of PERC outputs have been generated based on audience, emerging policy, and organizational needs:

- Peru: three outputs were produced, a full report and two policy briefs, targeted at national policy discussions related to resettlement and recovery spending, in the aftermath of the El Niño Costero flooding. All materials were produced in both Spanish and English.
- Houston, Texas, U.S: three outputs were produced, a full report and two briefs, focused on business preparedness for disasters and the role of small businesses in recovery, in the aftermath of Hurricane Harvey.
- Malawi, Mozambique, and Zimbabwe: seven outputs were produced, including a full report, a standalone Executive Summary, and five country-specific policy briefs, focused on critical policy and funding gaps, strengthening early climate information and early warning systems, and improving disaster risk reduction programming in the aftermath of Cyclones Idai and Kenneth.

Individual PERCs have also been followed by blogs that present key lessons learned and recommendations for lay audiences.

These outputs are available at: https://floodresilience.net/perc

6 Consolidated PERC findings to date

More aggressive land use planning and nature-based solutions are urgently needed to reduce risk prospectively by reducing development in hazardous areas

Despite the rich and varying context in which PERCs have been conducted, ranging from small-scale, high-intensity flash floods with a surprisingly large number of fatalities (Germany 2016), large-scale cyclones that led to catastrophic flooding across vast areas (USA 2017 and 2018, South East Africa 2019), to rainfall-induced flooding in emerging country contexts (Morocco, 2014) or highly vulnerable countries and remote regions (Nepal 2014, Peru 2016 and 2017), there are many commonalities and recurrent findings. Disasters have much more in common than just the devastation of lives and property they leave behind – they all teach many of the same hard lessons. We have published several summaries of these lessons learnt (Zurich Insurance Group, 2019 and 2020; Keating et al., 2016[6]); in this section we discuss a few of the highlights from these more extensive studies.

The most recurring or pressing issues that we have seen across the globe include:

Disaster risk management, particularly flood disaster risk management, is playing catch-up as natural hazard risk increases. Climate change is increasing hazard intensity, frequency and/or duration of events. Both material exposure and the vulnerability of this physical capital is increasing despite a slowly growing awareness that there is nothing 'natural' about 'natural hazards' and that the impacts of hazard events can be avoided through risk reduction and planning. PERC studies highlight in particular that "managed risk" is accumulating behind levees, canals and reservoirs. More aggressive land use planning and nature-based solutions are urgently needed to reduce risk prospectively by reducing development in hazardous areas, thereby reducing exposure.

Globally, spending on response is still far greater than investment in pre-emptive risk reduction strategies. Individuals, businesses, communities, civil society organizations and governments all suffer from false incentives which lead to a lack of investment in pre-event risk reduction. Correcting these will require multi-stakeholder initiatives.

Where money is invested on prevention, it typically goes to protecting physical structures rather than more cost-effective flood risk management approaches such as environmental planning and nature-based solutions. These 'softer' approaches can fundamentally reduce flood risk and help communities learn to live with water in ways that result in fewer losses and damages during floods.

Infrastructure protection already in place – levees, for example – can both underperform and produce a false sense of security. Some element of this has been seen in every flood PERC we have conducted. Protection infrastructure is too often poorly maintained, leading to failure in the face of challenges well below design capacity. Safe failure mechanisms, either mechanical or operational, are often lacking. Consequently, failures, when they occur, can be severe and contingency plans and early warning lacking. These failures are compounded by the fact that levees and other types of physical defenses lull people into a false sense of security and induce asset build-up in the "protected" area. As a result, total risk increases behind the levee while at the same time alternative measures and behaviors to cope with flooding are forgotten or unpracticed, resulting in catastrophic impacts.

The vulnerability of critical infrastructure needs to play a more prominent role in disaster risk management. Cascading failures from infrastructure such as transportation, energy production and/or energy distribution were observed in almost every PERC, leading to further cascading failures where users lost access to linked systems and suffered from often severe and long-lasting indirect losses. Such failures can send shockwaves through local economies, stifling recovery.

Few incentives exist to encourage "building back better" or including resilience in the rebuilding process. The futility of rebuilding to the same level of risk after a disaster and the benefit of using reconstruction to rebuild to a better standard is intuitively simple but difficult to implement for many different reasons including complexity of government schemes, the speed and timeframe with which building back better incentives and subsidies can be applied for and implemented, and the lack of certified products or a certification process.

The poor and marginalized typically suffer the most and are aided the least both before and after disasters. Recovery mechanisms generally prioritize rebuilding physical structures and critical infrastructure, and rarely account for the recovery needs of households and communities, despite the fact that livelihoods have been destroyed and assets have been lost. PERCs focused on larger disasters uniformly find communities and households have not fully recovered from previous events when the next one strikes.

[6] Summary of wildfire PERCs forthcoming.

Early warning saves lives and assets, especially in high vulnerability contexts, but only if they operate within an effective early warning system and lead to appropriate action. The presence of a system alone is not enough to ensure that it will function as it should. It must be structured to properly consider the threat of disaster and be quickly and efficiently communicated to those in harm's way such that they understand the risk and the actions required of them, which in turn must be realistic to implement.

Coordination and collaboration are critical to saving lives and assets and reducing risks. In both high and low-resource settings, PERCs have highlighted how strong collaboration between community-based organizations, NGOs, and local, regional and national governments can help minimize the impacts from a hazard event. Both pre-planned coordination between existing groups and collaboration between existing structures and emergent groups play a critical role in response and recovery around the world.

Just because an event has not yet happened in a particular location does not mean it couldn't. In March 2019, Cyclone Idai hit central Mozambique. The strong winds severely impacted the port city of Beira, and torrential rains created an inland ocean miles across. Similarly, Hurricane Harvey in 2017 was not just a wind, but mostly a flood event of a scale not anticipated. Yet, though these particular events in these locations were unprecedented (in recent historic times), the event and the subsequent impacts were not unthinkable. It is reasonable to assume that awareness, risk reduction and preparedness programs would benefit many other areas where such a severe event can occur but where it has not (recently) happened.

Box 7. Consolidated PERC wildfire findings

Just as there are common themes that have emerged from the collection of flood PERCs, there are striking similarities in terms of key insights and recommendations from wildfire disasters that can inform businesses and communities globally. The three wildfire PERC studies aim to help broaden the perspective on wildfire risk management beyond only ex-post reactions such as emergency response, and identify adaptation requirements across the risk management cycle, with a focus on land-use and community resilience.

1 Both fire hazard and fire risk overall is changing. The wildfire PERC studies conducted to date show a clear climate signal in all three events. New fire regimes are emerging in terms of seasonality, duration and intensity. If we want to better forecast future fire risk, take appropriate action, and maintain a certain level of protection, we need to accept that relying on historical data is not enough to understand future fire hazard and risk. Fires are burning longer, stronger and in multiple locations at the same time; firefighting intervention strategies, wildfire mitigation, building codes, and other fire mitigation and adaptations have not yet evolved to address this new reality.

2 Wildfire risk management, like risk management for any natural hazard, is a team effort that needs coordination across users, institutions and political and administrative boundaries. Fires respect no borders, and prevention is key in any risk management strategy. It is important to take an integrated resilience approach to wildfires and not just look at wildfire mitigation and response to fires that are already burning. Wildfire in particular is one peril where a citizen action can have a tremendous effect on the resilience of the overall community, as fire performance can depend on how a single property interacts within the Wildland Urban Interface (WUI). The WUI is a decisive zone to understand how fires halt or spread. Building materials, landscaping maintenance and the choice and positioning of vegetation are key determinants for this.

3 Beyond the immediate intensity of the fires themselves, the fire PERCs highlight the knock-on, secondary and tertiary effects that have far-ranging implications beyond the area burnt and direct fire impacts and losses. This includes physical and social impacts for individuals and households such as difficulties in recovering damaged or lost homes or returning to a "normal life". It includes institutional losses such as the loss of core water distribution or communications infrastructure coupled with the loss of the taxpayer base to support even operation let alone reconstruction. Finally, the timeframes involved in widespread fire recovery are proving to be even slower than flood recovery, with cascading implications for loss of community, loss of businesses, and loss of livelihoods.

7 Conclusion

In this manual, you have been provided with the necessary information on process and relevant tools to conduct your own post-event review using the PERC methodology. Following many catastrophic disasters of regional and global scale in recent years, it has been widely acknowledged that forensic reviews and learning from events are crucial to avoid mistakes being repeated and to grasp opportunities to make things better next time. It is also important that learning can take place in an unbiased and flexible context – it should not come in the form of a checklist. The PERC process is not set in stone; rather, it can and should be modified and adapted to suit the context you are studying. This is important because all contexts are different. Using rigid sets of tools, methods and questions will only stifle the unanticipated yet important narratives that exist.

The benefit of conducting a PERC is that it looks at disasters from a systems-wide lens, synthesizing lessons learned across sectors and scales, utilizing an unbiased perspective and tone, following the leads that the facts present – this is why it is called a forensic analysis. While we have found that a PERC is never really complete, the goal of each study is to assemble the fullest possible picture of what happened, why it happened, and what opportunities for action exist. It is not the goal of the PERC to design specific interventions that deal with the minutiae; rather, it is to point out wider trends and systemic gaps for which on-the-ground disaster risk management practitioners can design interventions and/or strategize advocacy.

Ultimately, the goal of a PERC is to inform and encourage resilience-building processes that prevent hazards from becoming disasters. In the face of growing risk, PERC is an important tool for disaster risk management, disaster risk reduction and climate change adaptation practitioners and researchers, one they can use to tackle increasing burdens from disasters.

Glossary

Adaptation – Responding or adjusting to risk in a way that reduces potential damage or loss, makes the most of resulting opportunities, and helps better cope with the consequences.

Agents – People and their organizations, whether as individuals, households, communities, private and public sector organizations, or companies, and their capacity to respond to and shape the world around them.

Capacity – The ability to do a specific thing, which requires having the appropriate knowledge, skills, and resources.

Cascading failures – When failures in a system lead to a series of failures in the same or other systems such that the systems then fail to provide the intended services to their users. For example, flooding of a power plant or transformer station leading to failures in an electricity system which lead to failures across a range of systems that rely on electricity to function, including but not limited to water treatment, communications, and transportation.

Corrective risk reduction: The actions taken to reduce risk to already at-risk assets, such as building levees to better protect existing assets or upgrading the construction of a house so it better withstands flooding.

Damages and losses – The impact to human, financial and physical assets by an event. Damages and losses are frequently calculated in terms of financial losses resulting from the disaster, number of people injured or killed, and homes and infrastructure damaged or destroyed. Damages and losses can result from both direct and indirect impacts.

Direct impact – The impacts through a direct interaction between a shock or stress and a physical, economic, social, or political component. In the case of flooding, this includes people injured or killed and homes and infrastructure destroyed due to floodwaters.

Disaster – "A serious disruption of the functioning of a community or a society involving widespread human, material, economic or environmental losses and impacts, which exceeds the ability of the affected community or society to cope using its own resources" (UNISDR 2009). Disasters occur when hazards interact with a combination of social, political, economic, environmental and physical factors to cause losses and damages.

Disaster forensics: Disaster forensics borrows the term forensics from the field of scientific applications to criminal investigations and applies it to study the "anatomy of disasters" (Disaster Forensics, Springer, 2019). Disaster forensics describes a consistent, comprehensive analysis of a large natural hazard or human-caused event and its underlying causes, actions (or inactions) and behaviors within a complex system of norms, institutions, and actors in the lead-up to, during, and following the event. While enabling a systematic approach, disaster forensics is open to new insights (for example, understanding a recent build-up of risk in an area) and encourages a diligent and flexible analysis.

Disaster risk management (DRM) cycle: The systematic process of using administrative directives, organizations, and operational skills and capacities to implement strategies and policies and improve coping capacities to avoid, lessen, or transfer the adverse effects of hazards. The cyclical nature of the DRM cycle means that the stages of the cycle blend into one another. We define five stages of the DRM cycle: preparedness, response, recovery, prospective risk reduction, and corrective risk reduction.

Disaster risk reduction (DRR) – "The concept and practice of reducing disaster risks through systematic efforts to analyze and manage the causal factors of disasters, including through reducing exposure to hazards, lessening vulnerability of people and property, wise management of land and the environment, and improving preparedness for adverse events" (UNISDR, 2009).

Early warning system – A system that provides people with advance warning of a potentially hazardous event occurring, giving people time to protect themselves, important assets, and important services.

Ecosystem services – If we use natural capital to provide a service to a user (such as an individual, group, or society), that service is an ecosystem service. Services can be for provisions (food and water), for support (providing air or nutrients or an environment for a particular service), for culture (such as recreation, spiritual, etc.) and for regulation (e.g. flood protection, water filtration, etc.).

Exposure – "People, property, systems, or other elements present in hazard zones that are thereby subject to potential losses" (UNISDR, 2009).

Financial capital – The level, variability, and diversity of income sources and access to other financial resources that contribute to wealth.

Flood – An overflow of water beyond its normal limits, especially over what is normally dry land. Flood types can include flash floods, river floods, coastal floods (from storm surge, high tides, and/or increasingly, from sea level rise), and surface floods (from heavy rainfall, elevated groundwater levels and/or poor or blocked drainage).

Flood resilience – an outcome that ensures that a community can continue to thrive and develop in the face of flood risk. In other words, if a flood-prone community has resilience, its development will not be derailed due to flooding. More specifically, we define Disaster 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.[7]

Hazard – A substance, object, or situation that can give rise to injury or damage. Hazard is the potential for threat to life or property. For example, to create (flood) risk, a natural or flood hazard, e.g., from rivers, the sea or from surface water runoff after intense storms, needs to be present first. Hazards can be natural or non-natural. Natural hazards are caused by weather, climate, and geophysical drivers; non-natural hazards are caused by social, political, economic and technological failures. Flood hazard is a specific type of natural hazard, can be expressed as the probability of flood occurrence at a given location, and can be modeled or mapped using flood maps.

Human capital – The education, skills, and health of a group of people.

Indirect impact – An impact due to a secondary interaction between a shock or stress and a physical, economic, social, or political component, or an impact resulting from a complex pathway of impacts. In the aftermath of disaster, indirect impacts could include business losses arising from customers spending less money as they recover from the disaster, or indirect physical consequences from a flood due to water contamination (not effects that the flood waters caused directly).

Institutions – The rules, norms, beliefs, and conventions that shape or guide human relations and interactions, access to and control over resources, goods and services, and assets, information, and influence. Legal norms are the formal rules and regulations created by legislative and administrative bodies. Cultural norms are informal rules, or social and cultural expectations, that govern human behavior.

Land-use planning – Formal management of land development by mandated authorities. Ideally, land-use planning should ensure that land use minimizes exposure to hazards.

Levee effect – When the presence of flood protection structures such as levees result in increased development in the floodplain or in the 'shadow of the levee', thereby increasing potential losses and damages during floods if the protection structures fail. The levee effect reduces short-term risk but increases long-term risk and possibly increases total risk due to a false sense of safety behind a protection structure. A more detailed description of this phenomenon can be found in Tobin (1995).

Magnitude – A measure for the relative size of something. In terms of natural hazards, magnitude often means the extent or severity of a specific natural hazards event. This more general term is not to be confused with the specific term magnitude when discussing earthquakes.

Natural capital – The natural resource base, including land productivity and actions to sustain it, water, clean air, fisheries, forests, and other resources that sustain livelihoods and wellbeing.

Physical capital – Things produced by economic activity from other capital, such as infrastructure, equipment, improvements in crops, and livestock.

Physical protection structures – Structures built to mitigate hazard impacts or prevent hazards from reaching settlements and important assets. In the case of floods, physical protection structures include levees, dikes, embankments, and sea walls, as well as nature-based protection like bio-dikes, engineered reefs, and intentionally planted or maintained mangrove forests.

[7] See Keating et al. (2017) 'Disaster resilience: what it is and how it can engender a meaningful change in development policy' Development Policy Review vol. 35, issue 1, pg. 65-91.

Preparedness – Precautionary actions taken prior to events that could turn into disasters. At the household level, this could include understanding your risk and knowing what resources you have and actions you can take to mitigate that risk (such as getting papers and equipment raised off the ground when you receive a flood warning). At the community level, this could include establishing evacuation routes. At the district or national levels, this could include humanitarian agencies prepositioning emergency relief supplies.

Probability of occurrence – The probability, typically expressed in percent per year, that a particular hazard event will occur. It is the inverse of the return period. For example, major infrastructure like hydropower dams are typically built to withstand 1-in-100-year events, or events with a 1% annual probability of occurrence.

Prospective risk reduction – Actions taken to avoid the build-up of new or increased risk, for example implementing and enforcing building regulations and land use planning to avoid new construction in hazardous places.

Rapid onset hazard – Hazards that arrive rapidly with little or no warning such as flash floods or earthquakes.

Recovery – The actions taken after a disaster (either in the short- or long-term) to help people cope with disaster impacts, reconstruct damaged physical systems (e.g., homes, roads, damaged flood protection structures) and restore services.

Resilience – "The ability of a system, society or community to pursue its economic and social development and growth objectives while managing its risk over time in a mutually reinforcing way" (Keating et al., 2014).

Response – The actions taken during and immediately after a disaster to contain or mitigate disaster impacts, including evacuation, search and rescue, emergency relief distribution, and first aid.

Return period – The long-term average period between events of a given magnitude or probability, e.g., a one-in-100 years return period would indicate an event that *on average* occurs once every 100 years. It is important to recognize that this does not mean that the event will only happen once in a 100-year period, or once every 100 years. Two 100-year flood events could happen more in the same year, and once a year over several years in a row. To better understand the flood probability, a 'one percent annual chance' is better-suited to expressing the situation. A 100-year flood is simply a statistical benchmark indicating the type of event that has a 1% probability of occurring in any given year. The water level of a 100-year event may be referred to as HW100 and the corresponding floodwater flow as HQ100.

Risk – The probability of an event combined with the negative consequences that people and systems will suffer if that event occurs. Risk is the potential loss, assessed in terms of impact severity and occurrence likelihood. Flood risk is thus the combination of a flood hazard and its occurrence in an area of exposed assets or people that can be harmed to different degrees depending on their vulnerability. In short, risk is determined probabilistically as a function of hazard, exposure, and vulnerability. It can also be expressed as the product of the event probability times the severity of the consequences.

Semi-structured interview – A relatively open interviewing method where there is not a pre-determined set of questions. Rather, there is a set of guiding questions and the freedom to pursue otherwise unforeseen topics.

Sendai Framework – The Sendai Framework for Disaster Risk Reduction (SFDRR) 2015-2030 is the roadmap for how communities can be made safer and more resilient to disasters. It is administered by the United Nations Office for Disaster Risk Reduction (UNDRR). SFDRR promotes the urgent need for learning from disasters. It advocates for *"the substantial reduction of disaster risk and losses in lives, livelihoods and health and in the economic, physical, social, cultural and environmental assets of persons, businesses, communities and countries" and explicitly mentions the importance of learning from disaster events in two of its priorities, where "the sharing of expertise, knowledge, post-disaster reviews*

and lessons learned" is critical to […] *"promote disaster risk management into post-disaster recovery and rehabilitation processes"* and *"to advance science and technology"* […] it is necessary to "*use post-disaster reviews as opportunities to enhance learning and public policy"*.

Snowball sampling – A non-probabilistic sampling technique where subjects (in this case, for interviews) are chosen based on a referral system. Interviewees suggest other potential interviewees.

Social capital – Social relationships, networks, and bonds that aid cooperative action, sharing of assets, and access to ideas and resources.

Systems – Includes ecosystems (e.g., agricultural fields, forests, grasslands, riparian river corridors, etc.) and infrastructure systems (e.g., build infrastructure, power generation and distribution, water purification and distribution, wastewater treatment, communications, etc.), and the services they provide.

Vulnerability – "The characteristics and circumstances of a community, system or asset that make it susceptible to the damaging effects of a hazard" (UNISDR, 2009). Vulnerability is driven by a combination of physical, social, economic, and political factors

Vulnerable people/groups/population – Vulnerable groups can be defined by their diminished capacity to anticipate, cope with, resist and recover from the impact of a natural or man-made hazard. The concept is relative and dynamic. Vulnerability is most often associated with poverty, but it can also arise when people are isolated, insecure and defenseless in the face of risk, shock or stress. Examples of potentially vulnerable groups include: displaced populations who leave their habitual residence in collectives, usually due to a sudden impact, disaster, or conflict, as a coping mechanism and with the intent to return; migrants who leave or flee their habitual residence to go to new places; specific groups within the local population, such as marginalized (see 'Marginalized'), excluded, or destitute people; young children, pregnant and nursing women, unaccompanied children, widows, elderly people without family support, disabled persons. In a disaster, women in general may be affected differently from men because of their social status, family responsibilities or reproductive role, but they are not necessarily vulnerable; they can also be resourceful and resilient in a crisis and play a crucial role in recovery. Gender analysis can help to identify which women or girls may be vulnerable and in what way.

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About the Zurich Flood Resilience Alliance

The Zurich Flood Resilience Alliance, a multi-sector partnership focusing on finding practical ways to help communities strengthen their resilience to floods globally – and save lives, was launched in 2013. In the first phase of the program, we have reached over 225,000 direct beneficiaries across our 13 programs in nine countries.

In the second five-year phase of the program launched in July 2018, the Alliance aims to increase the investment going into pre-event resilience building by USD 1 billion and commits to scaling up its work in climate action, to help make 2 million people more resilient to flooding, both by the end of 2023. We already know that every USD 1 invested in prevention saves on average USD 5 in future losses. We do this by rolling out best-practice community programs that demonstrate the value of resilience-building; compiling best practices and success stories; and advocating for more investment in resilience with authorities and public and private funders. We share our knowledge on our own flood resilience portal.

This Alliance is now comprised of nine members – Zurich Insurance Group working with the civil society and humanitarian organizations Concern Worldwide, the International Federation of the Red Cross and Red Crescent Societies (IFRC), Mercy Corps, Plan International and Practical Action as well as research partners the International Institute for Applied Systems and Analysis (IIASA), the London School of Economics (LSE) and the Institute for Social and Environmental Transition-International (ISET). Funding for our Alliance partners is provided by the Z Zurich Foundation.

About PERC

As part of the Zurich Flood Resilience Alliance, the Post-Event Review Capability (PERC) provides research and independent reviews of large disaster events. It seeks to answer questions related to aspects of resilience and disaster risk management. It is a flexible method that analyses the root causes of why events become disasters. It looks at what has worked well (identifying best practice) and opportunities for further improvements. Since 2013, PERC has analyzed various flood and wildfire events and won two awards. It has engaged in dialogue with relevant authorities, and is consolidating the knowledge it has gained to make this available to all those interested in progress on disaster risk management.

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