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Measuring flood resilience – our approach

Working together to tackle the challenges of floods

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Floods affect more people globally than any other natural hazard; they can literally 'wash away' overnight what communities have gained over years in terms of development and growth. Responding to this challenge, in 2013 Zurich Insurance Group (Zurich) launched a global flood resilience program. The program aims to advance knowledge, develop expertise, and design strategies to help communities improve their ability to deal with recurring floods.

To achieve the program's goals, Zurich formed a multi-year, interdisciplinary alliance of five organizations:

- **Zurich** provides the funding for the program, as well as contributing its risk management and risk engineering expertise.
- **International Federation of Red Cross and Red Crescent Societies (IFRC)** run community flood resilience programs in Mexico and Indonesia, and provide an opportunity to take best practice across the Red Cross's 189 National Societies. The societies also have close ties to national governments and can help guide national policy and practice in disaster risk reduction.
- **International Institute of Applied Systems Analysis (IIASA)** provides an academic research program focusing on disaster management in a systems context, especially in the developing world.
- **Practical Action**, a UK-based international non-governmental organization (INGO), runs community programs in Nepal and Peru. Practical Action's approach provides opportunities for technical innovation. It also has processes and expertise that support the program, allowing it to share what we learn more widely.
- **Wharton Risk Management and Decision Process Center** contributes through its academic research program with a focus on disaster management, especially in the developed world.

Drawing on alliance members' complementary skills, we aim to increase knowledge and gain experience in community flood resilience. We thus provide insights that all stakeholders can learn from and apply. By 'incubating' ideas and sharing them, we can influence how the impacts of floods are tackled on a global scale.

Cover: Participants from organizations around the world came together in Zurich for the measurement training workshop.

Photo credit Michael Szönyi.

The concept of resilience

Rather than merely alleviating the 'symptoms' of flood disasters through post-event recovery, evidence from a number of projects and studies suggests that it is more cost effective to address the underlying problems that result in flood losses.[1] International agreements put in place since 2000 have created an ambitious platform to tackle the risks posed by such disasters. But, apart from some success in lowering global disaster mortality, there appears to have been little tangible progress in remedying the underlying causes.

Resilience bridges two seemingly conflicting goals to achieve the best of both worlds, encouraging strategies that both manage risk and promote development. By focusing on resilience, the Zurich Flood Resilience Alliance can help achieve sustainable, positive change. Bringing together skills from across public, private and humanitarian sectors, we can identify and implement strategies to enhance community flood resilience.

Measuring resilience

The key challenge is to demonstrate that the work we do has the desired impact. But how can resilience-building initiatives be measured? This is no easy task. As of 2014, no general measurement framework for disaster resilience had yet been empirically verified,[2] according to the United Nations Development Programme (UNDP). While many organizations are looking for ways to measure resilience, and some have created specific tools that attempt to define indicators and assessment processes, few have moved beyond a theoretical concept based on only a few case studies. Even where an operational model appears to be in place, there is no evidence that what is being measured is, in fact, resilience.

Seeking to find a way to address this challenge, we formed a working group to develop a measurement framework and corresponding tools to measure flood resilience. By doing so, we aim to demonstrate empirically that ex-ante measures are more effective than ex-post ones. Acting to stem losses and increase resilience before a flood (ex-ante) as opposed to recovery after a flood (ex-post) is especially vital at the community level.

> We define 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 way that contributes to sustainable growth and helps to mitigate disaster risk.[3]

At least four factors must be taken into account when measuring resilience: There is no one-size-fits-all solution or tool; resilience is too big a concept to be measured in its entirety; efforts to increase resilience in one part of a system may undermine resilience in another; and any system measuring resilience should apply to a specific peril. Keeping these points in mind, and based on our knowledge and expertise as an insurer, we decided that we would focus on a single hazard – floods.

A community focus

Since floods have the most immediate impact on communities, our involvement at this level lets us demonstrate the tangible, positive impact that increasing resilience can have on people's lives. And, by working with communities, we can create best practices from the ground up to shape and influence policy at a higher level.

[1]Hallegatte, S. (2012) A Cost Effective Solution to Reduce Disaster Losses in Developing Countries: Hydro-Meteorological Services, Early Warning, and Evacuation, World Bank Policy Research Working Paper, No. 6058, The World Bank, Washington.

[2]Winderl, Thomas. Disaster Resilience measurements: Stocktaking of Ongoing Efforts in Developing Systems for Measuring Resilience, 59pp. United Nations Development Programme, 2014.

[3]Keating, A., Campbell, K., Mechler, R., Magnuszewski, P., Mochizuki, J., Liu, W., Szoenyi, M. and McQuistan, C. (in press) "Disaster resilience: what it is and how it can engender a meaningful change in development policy" Development Policy Review.

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But what makes up a community? In rural areas, for example, a 'community' could be defined geographically, while administrative boundaries may work in more urban situations. A community could also be defined in terms of social connections (for example, through trade, or how people and groups meet). However, no single community will 'feel' like another. Each one, just like every person, is an individual with its own characteristics.

Every community is unique and largely defined by its singular characteristics.

Developing a model – the 5C-4R framework

Our working group's research includes looking at the origins of resilience. From among the many conceptual models already developed to assess resilience, we chose to combine two to form what we describe as our '5C-4R community-based flood resilience measurement framework.'

The 5C model uses the 'five capitals' described in the UK's Department for International Development (DFID) 'sustainable livelihoods framework' (SLF). These '5Cs' characterize the assets a community consists of and are complementary resources that sustain and improve communities' wellbeing. If these are used well, they can increase personal and collective wealth, provide a sense of security, and enhance environmental stewardship.

The five capitals:

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

The 4R model developed by the Multidisciplinary Center for Earthquake Engineering Research (MCEER) at the University of Buffalo in the U.S. postulates that a system has four properties that determine resilience. Collectively known as the 4Rs, they were originally used in a built environment (one that comprises physical infrastructure), but we think they apply equally to all assets in a system; both tangible physical assets and less tangible ones.

The four properties of a resilient system:

- **Robustness** (ability to withstand a shock), for example, housing and bridges built to withstand a flood.
- **Redundancy** (functional diversity), for example, having many evacuation routes.
- **Resourcefulness** (ability to mobilize when threatened), for example, a group within a community that can quickly mobilize to convert a community center into a flood shelter.
- **Rapidity** (ability to contain losses and recover in a timely manner), for example, quick access to sources of financing to support recovery.

Resilience can come from many sources. For example, having a physical asset (a capital in the 5C model) such as a community center that doubles as a classroom during the floods adds 'redundancy' (a property in the 4R model) to the system, and so is considered a source of resilience.

When developing a practical, community-based flood resilience measurement tool, we have defined a set of these 'sources of resilience.' These can serve as proxies before a flood to measure how a community fares, or how it performs after a flood. How a community fares, or 'performs,' is referred to as 'the outcome of resilience.'

Measuring the sources of resilience

Over the years, Zurich's approach to measuring risk has evolved into a rigorous methodology. Zurich risk engineers use a technical risk grading standard (TRGS) to help make sense of the data they gather. The TRGS provides a consistent benchmark for quantifying risk. For any specific peril, a TRGS includes five to 10 risk categories. Each category is made up of several risk factors. Risk engineers compare the data to the benchmarks and, based on their professional judgment and experience, assign letter grades from A to D:

Risk grading scale:

- **A:** Best practice for managing the risk.
- **B:** Good industry standard, no immediate need for improvement.
- **C:** Deficiencies, room for visible improvement.
- **D:** Significantly below good standard, potential for imminent loss.

With the Alliance's expertise, this measurement methodology has been adapted to assess communities' resilience to flooding. The approach combines quantitative and qualitative data based on the 'sources of resilience.' These can then be graded, and with the expertise of trained resilience assessors, based on the outcomes of the analysis, actions can be identified to enhance resilience.

The 'Five Cs' or 'Five Capitals' refer to five core asset categories that can be drawn on to improve the lives of people living in communities: human capital, natural capital, financial capital, physical capital, and social capital. A key part of the work the flood resilience alliance does with communities involves measuring resilience. This helps to establish whether actions to increase resilience are effective. For more, see 'Enhancing community flood resilience: a way forward' at http://knowledge.zurich.com/flood-resilience/risk-nexus-enhancing-community-flood-resilience-a-way-forward/

> The Zurich Flood Resilience Alliance has thus established a framework that can meet not only the challenges of measuring resilience, but can do it in an empirically verifiable way."

Once all sources are graded, it is also possible to identify strengths and weaknesses in the community and how each of these might contribute to resilience. Each 'capital' and each 'source' can be assigned a weighting in the overall measurement framework (please see appendix for all sources included in the Zurich Flood Resilience Alliance measurement framework).[4]

Road-testing the measurement framework

The measurement framework has already been piloted by our community organizations, Practical Action and the IFRC, in over 20 communities in Nepal, Peru and Mexico. Based on the results of these pilots, in 2014 and 2015 we refined the tool, in particular enhancing its usability. We also invited peers to an event to review the system in June 2015, at which academic and humanitarian experts from around the world were asked to critically evaluate it. Their review was overwhelmingly positive, but they also identified some key issues that we have since addressed – specifically, the need to more clearly define terms: resilience, communities, capitals – and providing better ways to assess complex data.

As part of our methodology, we also needed a set of tools to make the measurement framework practical and allow us to test it in a real environment. Our tool set provides a process for 'end-to-end' flood resilience measurement.

Tools to establish a process to measure resilience:

- A training environment allowing people to be trained in using the framework.
- A flexible (online, web-based) application to set up measurement activities, select data collection methods and assign them to fieldworkers' smartphones.
- A simple, practical smartphone-based application to collect the data through the collection methods chosen, store it and send it back to the web application once the job is completed.
- A web-based environment consolidating all data for the assessment, using our rigorous and consistent assessment methodology.
- A method for visualizing and analyzing the measurement results and the right guidance on how to interpret the results (and how to avoid misinterpreting them).
- A database to store the resilience measurement results for a comprehensive analysis, and allow a validation process to be started.

In addition to our core community organizations, four other organizations[5] are now using the measurement toolbox in their community development work in flood-prone areas. Together with the IFRC and Practical Action, we are building a community flood resilience database; the data will be analyzed to validate the sources of resilience and this knowledge

[4]In this version of the tool, we have decided not to weight any one source over another, or any one capital over another in terms of making up the overall scores. We currently have no evidence as to the relative significance of the sources of resilience. This may change as the data from the trial phase becomes available and provides insight onto which sources are more significant over others.

[5]Mercy Corps, Concern Worldwide, Plan International and the National Academy of Sciences.

will be used to further refine the methods. The Zurich Flood Resilience Alliance has thus established a framework that can meet not only the challenges of measuring resilience, but can do it in an empirically verifiable way.

Assessing the strengths and weaknesses of pilot communities

By assessing the 'sources of resilience,' the tool generates an overall score and some 'category' scores, which are obtained by converting numeric values to letter grades (A through D). The sources of resilience can be grouped together and analyzed according to different methods, as outlined here.

Ways to analyze sources of resilience:

- The five capitals (5Cs).
- The four resilience properties (4Rs).
- Ten themes, effectively the topics used to formulate questions asked in communities, such as health, education, food, governance, and similar.
- The five steps of the disaster risk management cycle.
- The context or environment in which a source is embedded – i.e., internal (community) or external (environment).

The tool will generate numerical results to assess a community's resilience level. But these scores should not be used to compare how communities 'compete' in terms of their resilience. Our resilience measurement framework is not an index and not suitable for ranking communities, a practice which could, if encouraged, lead to overly-positive results, or raise the risk that communities with low scores are 'abandoned.' The tool should only be used to help communities improve their resilience level by taking the right actions based on the results obtained.

Identifying, prioritizing and planning resilience-building actions

Identifying and describing factors that received a low resilience score, and determining how they relate to each other, can support and guide the process to increase resilience. Identifying community development priorities may be guided by this process, even though this is not its primary purpose. The method outlined here does not help users to automatically select interventions.

The outcomes of resilience – a validation approach

To demonstrate that we are building resilience, ultimately we need to verify that any actions we take have an impact. By using the framework described here to produce measurements between at least two points in time – comparing the end-line assessment with the baseline assessment (and possibly some mid-term assessments) – we can track changes in the sources of resilience. By comparing this change with empirical evidence about how a community manages during a flood event (gathered through a systematic review),[6] we may be able to attribute outcomes of resilience to their relevant, underlying sources. This is key to verifying the framework.

We will continue to test the tool and work to establish methods and processes that can be used by anyone with an interest in resilience measurement, who is also open to testing and sharing their experiences and the data they obtain.

[6]The Zurich Flood Resilience Alliance has developed a methodology to consistently assess what has happened during a flood event that turned into a disaster and why, the Post Event Review Capability (PERC). Learn more at https://www.zurich.com/en/corporate-responsibility/flood-resilience/learning-from-the-post-flood-events

Appendix

The 88 sources of resilience used in our approach, divided according to the five capitals, as listed in Table 1.

Table 1: 88 flood resilience sources

Human capital	Social capital	
Flood protective behavior and knowledge	Social participation in flood management related activities	Functioning and equitable waste collection and disposal services
Personal safety	Formal community emergency services integrate flood advice and management	Strategy to maintain or quickly resume local waste collection and disposal services in the event of a flood
First aid knowledge	Access to external, formal flood related services	Appropriate and equitable access to energy
Value of education	Strategies for the delivery of actionable information for flood management	Functioning and equitable water services
Flood Water Control Knowledge	Social norms and personal security	Strategy to maintain or quickly resume local energy supply in the event of a flood
Flood exposure perception	Functioning and equitable health system	Community representative bodies/structures for flood management coordination
Flood exposure management knowledge	Strategy to maintain or quickly resume healthcare services interrupted by flooding	Social inclusiveness
Flood vulnerability perception and management knowledge	Functioning and equitable education system	Social leadership
Understanding of future flood risk	Strategy to maintain or quickly resume schooling interrupted by flooding	Culture for community information sharing
Non-erosive flood recovery knowledge	Mutual assistance systems and safety nets	Village or district flood plan
Flood water and sanitation (WASH) knowledge	Social norms and security of assets	Coordination mechanism across communities
Waste management awareness	Appropriate and equitable access to mobility	Watershed/basin scale management plan and structure
Political awareness	Strategy to maintain or quickly resume provision of mobility services in the event of a flood	National policy and plan for forecasting ability
Flood provisioning ecosystem services awareness	Functioning and equitable food supply systems	Government policies and planning and mainstreaming of flood risk
Population health status	Strategy to maintain or quickly resume provision of local food supplies in the event of a flood	Flood regulation and local enforcement
Educational attainment	Functioning and equitable water services	National environment conservation legislation
	Strategy to maintain or quickly resume provision of local safe water in the event of a flood	Community plan for the sustainable management of natural resources and preservation of ecosystem services

Physical capital	Natural capital	Financial capital
Access to healthcare facilities	Basin health	Household financial savings that protect long term assets
Early Warning Systems (EWS)	Habitat connectivity	Income and affordability
Measurement and Forecasting	Natural habitats maintained for their flood resilience services	Communal social safety net
Flood emergency infrastructure	Sustainable use of natural resources	Household Credit Access
Access to school facilities	Conservation management plan	Business credit access
Individual (HH) flood vulnerability management	National legislation recognizes habitat restoration	Household flood Insurance
Communal flood protection (flood controls)		Business flood insurance
Basin level flood controls		Household income continuity strategy
Transportation and community access		Household budget management
Communication infrastructure		Continuity of business
Lifelines infrastructure		(Inter) National disaster response budget
Food security		Social safety net (legislative, national schemes)
Water supply		Mitigation financing (provided through public or private)
Sanitation facilities		Functioning financial market
Waste collection systems		Government appropriations for infrastructure maintenance
Energy sources		Community development investment vehicles
		Conservation budget


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