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Reflections on the large-scale application of a community resilience measurement framework across the globe

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ABSTRACT

This paper reflects on learnings and analysis from an extensively globally applied, standardized community disaster resilience measurement framework that utilises bottom-up (locally collected) data. These lessons, from over a decade of on-the-ground work and analysis, are based on empirical evidence and have salience for scholars, policy-makers and practitioners aiming to strengthen community disaster resilience and apply bottom-up community disaster resilience measurement approaches. The Flood Resilience Measurement for Communities approach was co-designed and implemented by the Zurich Flood Resilience Alliance: a transdisciplinary science-policy-practice collaboration including scientists, practitioners and private business. It has been applied globally in approximately 400 communities worldwide, demonstrating the real-world impact of scalable community disaster resilience measurement initiatives. Findings provide evidence for the impacts and good practices of applying bottom-up community disaster resilience measurement approaches. Quantitative analysis on this unique dataset provides new entry points for research on typologies and dynamics of resilience, based on empirical evidence on human, social, physical, natural and financial dimensions. Based on our analysis, we find that the use of bottom-up, multidimensional, standardized community disaster resilience measurement approaches is a worthwhile endeavour to support community disaster resilience strengthening.

1. Introduction

In this paper we reflect on our experience with the Flood Resilience Measurement for Communities (FRMC) approach. Developed by ten partners and applied in approximately 400 communities across 29 countries over 11 years, the FRMC is, to the best of our knowledge, one of the most widely applied bottom-up, standardized community disaster resilience measurement frameworks in the world. Learnings based on analysis of the community-derived qualitative and quantitative data generated from this extensive application of a resilience measurement approach is timely; while investment in community resilience-strengthening initiatives and measurement approaches have recently proliferated, there remain gaps in empirical evidence on how to measure and strengthen community resilience over time (Linkov and Trump, 2019).

We provide insights regarding the challenges and benefits of taking a transdisciplinary, systems-based approach to co-design and implementation of a bottom-up community disaster resilience measurement framework and tool; evidence for the impacts of measuring community disaster resilience across multiple dimensions using locally collected data on communities and user organisations, and; findings from quantitative analysis using this unique dataset. Findings shared in this paper apply particularly to community- or neighbourhood-level disaster resilience measurement approaches applied within the context of community development, that are based on locally collected data and locally applied processes. Insights presented here provide further evidence, including quantitative evidence using this unique dataset, to findings from other approaches (see McAllister, 2015; Ellingwood et al., 2019; ARUP, 2014; UNDP, 2013; Prevention Institute, n.d.; UN-Habitat, 2021; Burton et al., 2017).

Approaches such as the FRMC, applied at the community or 'meso' level, that explore resilience across multiple dimensions (human, social, physical, natural and financial systems) and incorporate community voices via locally collected data, provide several useful entry points to

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explore resilience at the local scale from a process-based, “metrics that matter” perspective. This perspective is currently seen as a promising way forward to achieve targets in the global agenda, in particular the Sendai Framework for Risk Reduction, the Sustainable Development Goals, and the Paris Agreement (see Dilling et al. 2019).

The empirical evidence we present in this paper affirms the potential benefits of bottom-up, community disaster resilience measurement, that has been highlighted by theorists and in analyses of similar frameworks. There are challenges associated with bottom-up data collection and assessment including the time and resources involved, and issues of ensuring sufficient data quality (Hochrainer-Stigler et al., 2020), as compared to using externally available data. Notwithstanding these challenges, the benefits that come from local voices and processes being central to the resilience measurement approach are profound. That is, that the resilience concept and locally-based resilience measurement are worthwhile even when external data are available. This is because they engender a systems perspective amongst local-level actors, bridge the science-policy-practice interface, uncover the underlying drivers of risk and inequities, connect local stakeholders, elevate social and intangible dimensions, and engender transformational actions (Laurien et al., 2022; Keating & Hanger-Kopp, 201920; Frankenberger et al., 2014; Pasteur & McQuistan, 2016; Sudmeier-Rieux, 2014).

Reviews of disaster resilience measurement frameworks find a proliferation of frameworks and tools (Koliou et al., 2018; Schipper and Langston, 2015; Asadzadeh et al., 2017; Cai et al., 2018; Jones et al., 2021), yet this central feature is also its central challenge: as a complex, multi-dimensional and invisible or latent characteristic until risk realizes, resilience is deeply challenging to measure and operationalize (see also Ellingwood et al., 2019; Sterling et al., 2017; Saja et al., 2019; Sharifi, 2016). Many frameworks for measuring and operationalising community disaster resilience with locally-based data are either not applied beyond a handful of case studies, or are highly context specific meaning scaling is not appropriate or prioritized. This is partly due to a sizeable gap between the more scientific assessment of resilience and the implementation challenges in real world applications, reflecting the different worldviews and processes of agents such as communities, practitioners, policymakers, scientists/researchers, and private sector entities. Therefore, evidence for how community disaster resilience can be locally measured and operationalised in practice – and effectively scaled – is limited. Insights from quantitative analysis of resilience measurement results across multiple contexts is likewise limited. It is for these reasons that the experience of the FRMC is important.

2. Measurement framework overview

Like other multi-dimensional, systems-based approaches to resilience measurement (see Laurien et al., 2022; Koliou et al., 2018 for overviews), the FRMC is based on a systems-based understanding of the interrelationships between community-level flood risk, flood risk management, and sustainable development, and how they support or undermine community flood resilience (see Keating et al., 2016). Approaching resilience from the perspective of complex adaptive systems is now widely accepted, for example the Future Resilient Systems program takes this approach to infrastructure systems in Singapore (FRS, 2025). The FRMC approach is based on locally collected data and embedded in local processes. This is because its core intention is to support community-based initiatives for strengthening flood resilience, within the context of community development. In order to achieve this, local voices must be heard and processes undertaken within the community engaging local stakeholders.

A unique feature of the FRMC is that it measures both pre- and post-event resilience using a standardised framework. Because disaster resilience (to all hazards) is invisible or latent until the event occurs, investigating the characteristics of a community which contribute to resilience requires collecting data both before and after an event. Therefore, the conceptual system-map of community flood resilience that captures the complex interactions between flood risk, flood risk management and sustainable development (Keating et al., 2016) was developed into a set of indicators called “sources of resilience” that measure community characteristics and capacity before a flood occurs, and a set of ‘outcome variables’ that look at impacts after a flood.

Similar to other index-based approaches to resilience measurement listed above, in order to measure ‘apples to apples’ across multi-dimensional concepts with many qualitative and difficult-to-measure intangible elements, each source of resilience or outcome variable is graded from D-A against a standardised rubric. The FRMC grading approach is a two-step process, where first raw data is collected in community using mixed methods, and then trained local practitioners grade the sources of resilience based on this data (see Fig. 1; Campbell et al., 2019). The FRMC framework was developed into an integrated, hybrid platform that allows the collection and measurement of data in the field by local program officers. The FRMC process leads users through a structured, step-by-step process that requires close engagement with the local community and its stakeholders at each stage. The platform then generates and visualizes results which means that the data generated can be easily understood and communicated.

3. Reflections on resilience measurement co-design

The FRMC was born from the objective of enhancing community flood resilience within a philanthropically funded consortium called the Zurich Flood Resilience Alliance. It was developed to be an initial assessment to identify needs, as well to track resilience changes over time. A team of practitioners from the international development and humanitarian sector, scientists, and risk engineers from the private sector came together to co-design the framework. The experience of co-designing and implementing the framework over many years has led to useful insights about this transdisciplinary participatory action research process. These are shared here in the hope that they can support others collaborating to support resilience strengthening.

Community disaster resilience emerges from complex system interactions at multiple scales and therefore robustly assessing it requires a sophisticated instrument. Realising the benefits of bottom-up, community-based measurement requires complex local processes to be successfully implemented. This means that in practice, measurement requires a substantial investment of resources; something that practitioners working with disaster-prone communities rarely have access to. Getting the balance right between framework and process comprehensiveness, and applicability, was a constant negotiation within the co-design team. The result of this creative tension is an imperfect compromise – the FRMC is not as conceptually complete as it might be, nor is it as easily applicable as it might be. Instead, it is both conceptually sound and practical (see discussion below), in a field where many frameworks are either too complex to be applicable or too simple to generate insightful results which can contribute to both local disaster resilience strengthening and generalized learning across contexts.

4. Insights on resilience measurement practice

Our extensive experience confirms that success in scaling bottom-up community disaster resilience measurement is dependent on the cost and ease of use by practitioners. The FRMC enables field teams to collect relatively complex data sets themselves without the need to engage expert consultants or survey companies. Users report that the structured approach to collecting community and local stakeholder voices, across multiple dimensions, generates a comprehensive view of community perspectives, values and preferences. The FRMC platform stores and organizes this wealth of locally-sourced information in a secure, integrated, web-based system. This has tangible benefits throughout the entire project cycle — from intervention planning, through design, to reporting. Users have reported that the ease of analysing and displaying results in multiple ways allows them to understand and accessibly share

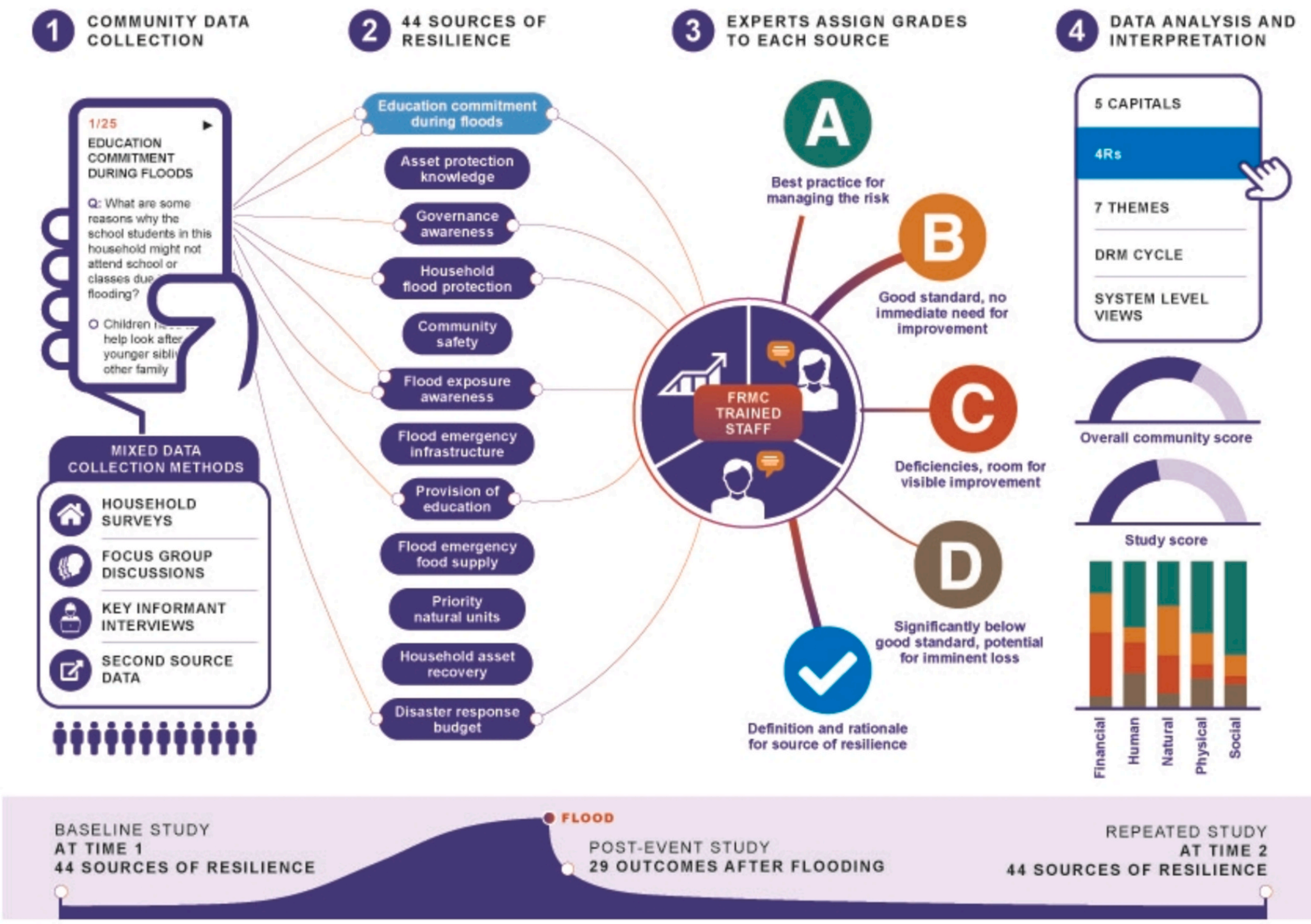

Fig. 1. FRMC process.

back results with the communities and other stakeholders. Importantly, the measurement results have also been found to be advantageous when applying for funds from other donors to scale up resilience building initiatives. Here we see empirical evidence in the resilience measurement space for the axiom that, "what gets measured gets managed" (Burton et al., 2017).

Numerous scholars and practitioners in the resilience measurement field have reported that the process of measuring resilience leads to capacity building (Devine-Wright, 2013; Plodinec et al., 2014; Sharifi and Yamagata, 2016; Steiner et al., 2018). Our qualitative analysis of feedback from practitioners across the 29 countries authenticates this finding at scale: we find that there is a strong learning and capacity building pathway that is developed through completing the FRMC process. By going through the steps of collecting and grading local data across multiple dimensions, in this case the five capitals – human, social, physical, natural, and financial – and then validating results with the community, both practitioners and community members see the bigger picture of resilience. The five capitals, as well as other design elements (themes, DRR cycle, 4R's) were intentionally built into the FRMC to help transform peoples thinking beyond entrenched silos of emergency preparedness or flood hazard mitigation, and to take an integrated and holistic view of community flood resilience. These capacities have multiple co-benefits for climate risk management more generally.

5. Results from resilience measurement data analysis

A unique feature of the FRMC is that it collects standardized information from local sources, and that it has been applied so extensively. This means that this unique dataset can be used to generate global evidence about community resilience-related needs and dynamics. Quantitative analysis of the FRMC data has been used to explore what this unprecedented dataset can tell us about community resilience across the globe.

Before empirically exploring the results of the FRMC applications, we note that questions of validity of the FRMC construct as a measure of community flood resilience have been and continue to be analysed. Hochrainer-Stigler et al (2020) explored the question of inter-rater reliability and test–retest, or how consistently grades were assigned across user teams, communities and time. They found more subjective judgement was used when assigning grades to sources of resilience that attempted to capture less tangible concepts. While there is always room for improvement in how data collection and grading rubrics are designed, they emphasise the importance of including these resilience themes in measurement because of their importance to community disaster resilience – even when subjective judgement is required, it is better to include these than not because, "what gets measured gets managed" (Burton et al., 2017).

Chapagain et al (2024) conducted a principle component analysis (PCA) to assess how consistently the FRMC measures resilience (disaggregated to the five capitals) across different contexts. They found high reliability for all capitals, except natural capital which fell slightly below the threhshold for construct reliability (Cronbach's alpha equal to 0.7, natural capital result was 0.69). This same analysis identified subthemes within each capital group, which further illuminate the dynamics of community flood resilience. Not only do these analyses support the validity of the FRMC as a bottom-up measure of community flood resilience, they also demonstrate creative and novel ways of empirically exploring the resilience construct regardless of the structure or intent of the measurement framework. By analysing flood resilience results according to community characteristics, we uncovered a flood resilience community typology (Laurien et al., 2020). This typology can be used to guide more general local decision-making processes as well as support community programming at larger (regional) and lower (household) scales. Specifically, we found that urban, *peri*-urban and rural communities have significantly different challenges when building flood resilience that need to be considered when designing flood resilience interventions (see Fig. 2). We also empirically found that the dynamics of resilience, i.e. changes in resilience capacities over time, significantly differs between different types of communities and therefore policy interventions have to be tailor-made according to the community at hand (Hochrainer-Stigler et al., 2021). Such information is also vital for targeting specific capacity needs for today and in the future including the need for transformational change.

Chapagain et al (2024) further extend this work, further disaggregating FRMC communities that have similar overall resilience levels but differ in their resilience profiles across capitals. Their analysis highlights a need for approaching community disaster resilience strengthening from a perspective of system dynamics across multiple scales, as articulated by Gunderson and Holling (2002).

From self-reports of past post-flood financial recovery time, we have also shown that the sources of resilience that are most highly associated with a faster financial recovery are in the financial and physical capital categories. Following a flood, having a household income continuity strategy was particularly important for recovery. Physical access to food markets was also found to support a faster financial recovery (Campbell et al., 2019).

As described above, in addition to measuring the sources of resilience, FRMC users also measure impacts, system performance and outcomes for communities after a flood event. This is called the post-event analysis and allows for empirical exploration of the relationship between pre-event characteristics measured the sources of resilience and post-event outcomes. Chapagain et al. (2025) conducted this analysis using data from 66 communities across seven countries, where both baseline and post-event studies had been completed. Providing further credence to the validity of the FRMC as a measure of community flood resilience, they found that higher resilience measured pre-event was correlated with lower flood impacts, while controlling for the severity of the flood itself. This analysis found that resilience outcomes are correlated with complex interactions between pre-event factors, highlighting the importance of a systems-based approach to resilience strengthening.

6. Conclusion and next steps

The bottom-up, holistic, systems-based approach of the FRMC and similar frameworks encourages practitioners to undertake a deeper analysis of the key strengths and areas of development in the community. This benefit is extended to local field staff, other stakeholders working with the user organization, and importantly, community members themselves. The bottom-up community disaster resilience measurement process fosters the awareness of the multiple and interconnected elements that contribute to resilience and encourages all involved to think about the future of risk and development in a systemic way. This cumulative and unprecedented global effort in applying and testing a bottom-up, standardized framework and tool in the field is providing a wealth of data from which important insights about

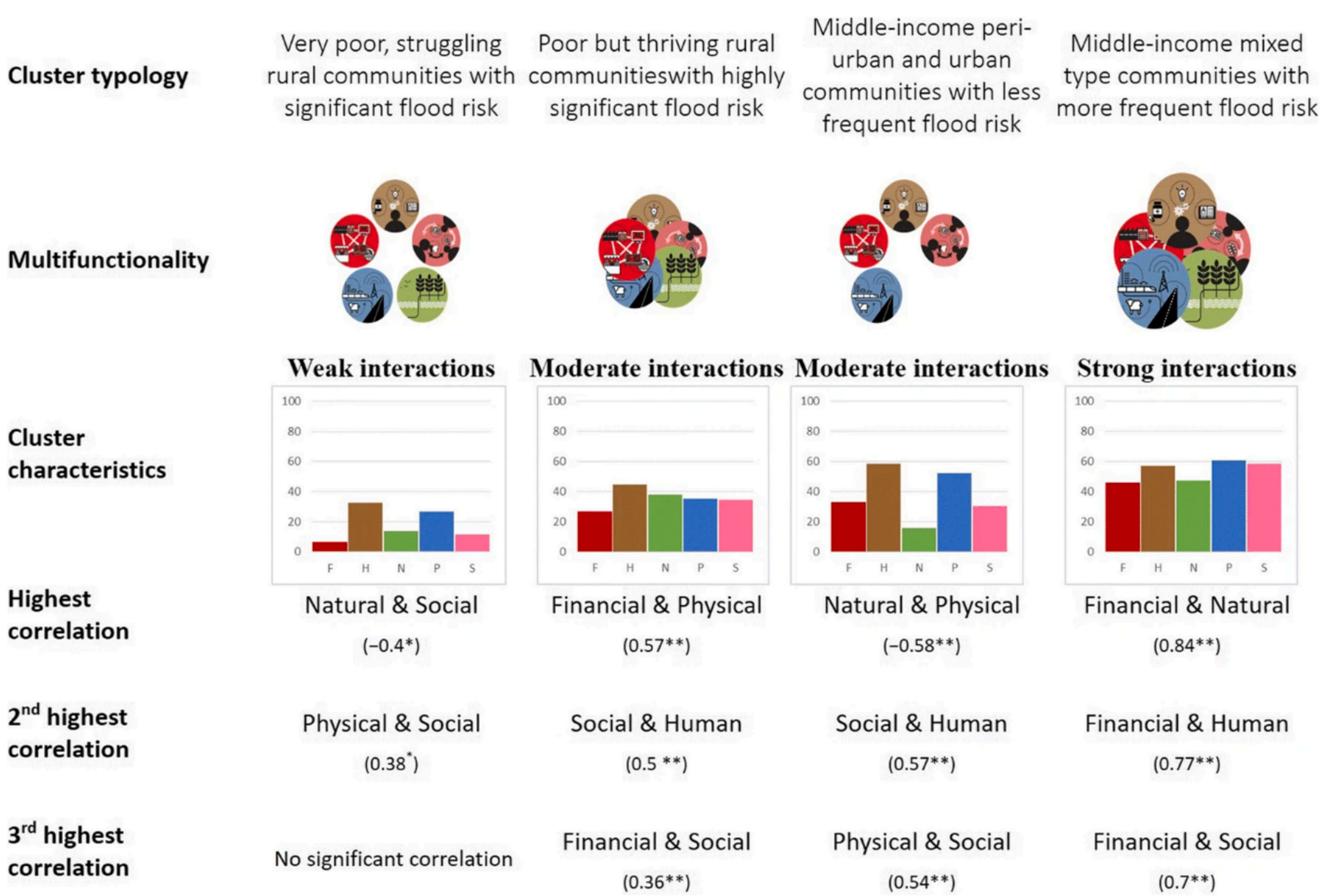

Fig. 2. Cluster types, cluster characteristics, and bivariate correlation analysis showing highly significant capitals both overall and between clusters. Pearson correlation analysis (two-tailed test): **correlation significant at the 0.01 level; *correlation source: Laurien et al., 2020.

community disaster resilience and resilience measurement, which continues to grow.

The learnings, analysis and successes presented here, together with an extensive peer review process, led the Alliance to conclude that it would be feasible and indeed desirable to expand the approach to hazards other than floods. The FRMC has now evolved into the Climate Resilience Measurement for Communities (CRMC) and is capable of measuring community resilience to flood, heatwave and/or wildfire (Zurich Climate Resilience Alliance, 2025). The development of the CRMC used an iterative co-design process and drew on our extensive on-the-ground experience and research. In developing the CRMC multi-hazard framework, it was deemed critical to adhere to key principles and structure of the FRMC, including hazard specificity (resilience of whom, to what, for what), community centricity, multi-dimensionality, and validation through measurements across multiple timeframes. Therefore, the CRMC measures resilience to multiple hazards in parallel. The CRMC is currently being piloted across the world, continuing the resilience measurement and strengthening journey that began in 2013.

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CRediT authorship contribution statement

Adriana Keating: Writing – review & editing, Writing – original draft, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Stefan Hochrainer-Stigler:** Writing – original draft, Supervision, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Reinhard Mechler:** Writing – original draft, Project administration, Funding acquisition, Conceptualization. **Finn Laurien:** Visualization, Formal analysis, Data curation. **Naomi Rubenstein:** Writing – original draft, Conceptualization. **Teresa Deubelli:** Writing – original draft, Conceptualization. **Stefan Velev:** Writing – original draft, Supervision, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Michael Szoenyi:** Project administration, Funding acquisition, Conceptualization. **David Nash:** Project administration, Funding acquisition, Conceptualization.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Adriana Keating reports financial support was provided by Zurich Insurance Company Ltd.

Data availability

The data that has been used is confidential.

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