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Measuring community disaster resilience for sustainable climate change adaptation: Lessons from time-series findings in rural Cambodia

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Abstract

Donor-funded climate and disaster resilience programmes and projects aim to help build the capacities and resilience of communities. Measuring resilience is critical, therefore, in providing feedback, evidence, and accountability. This paper presents recent two-year time-series findings from an ongoing multi-partner academic and practical collaboration pertaining to a climate change adaption project with rural communities in Cambodia. To measure community resilience, the study used the Flood Resilience Measurement for Communities, which measures, using mixed methods, disaster resilience capacities across five key dimensions of resilience: human, social, physical, natural, and financial capitals. The study analysed and reported changes in these areas of resilience in the selected villages, generating insights into the strengths and weaknesses of flood resilience capacities in the region. This paper provides valuable guidance as to where investment can be most effective in different communities, confirming the usefulness of the tool in measuring resilience and assessing the effectiveness of the project concerned.

KEYWORDS
climate change adaptation, community resilience, development cooperation, disaster resilience, project effectiveness, resilience measurement

1 | INTRODUCTION

With climate change increasing the frequency and severity of extreme weather events, interest in understanding and enhancing community disaster resilience (CDR) has grown in recent years. It has now emerged as a key concept in the fields of climate change adaptation (CCA), disaster risk reduction, and disaster risk management, as well as in community development more generally. Donor-funded climate and disaster resilience programmes and projects aim to reduce risk and help build the capacities and resilience of communities so that the impacts of shocks on people's lives and livelihoods will be minimised in the future. While resilience, based on its mounting influence across different fields, has become an overarching concept for research, policies, and practices (Sharifi and Yamagata, 2016), there are not yet many studies that measure it, let alone report any progress over time, particularly in developing country contexts—some examples are Mavhura and Manyena (2018) (Zimbabwe), Moradi, Nabi Bidhendi, and Safavi (2021) (Iran), and Pathak and Kulshresth (2021) (India).

If promoting CDR, as commonly understood, is a way to better mitigate, prepare for, respond to, and recover from disruptions and disasters (Ostadtaghizadeh et al., 2015; Schipper and Langston, 2015; Keating and Hanger-Kopp, 2020), assessing and measuring its changes, and scaling up insights (both achievements as well as challenges), are critical to help communities, project implementers, and policymakers alike to enhance such resilience. While many earlier studies have proposed various resilience frameworks (see, for example, Cutter et al., 2008; Twigg, 2009; Cutter, Burton, and Emrich, 2010; UNDP, 2017; Cai et al., 2018; Kendra, Clay, and Gill, 2018; Mavhura and Manyena, 2018; Marzi et al., 2019; Oriangi et al., 2021; Parsons et al., 2021; Abdul-Rahman et al., 2022), few have addressed community-level resilience or identified context-specific interventions that contribute practically to capacity-building (Bakkensen et al., 2017; Jones et al., 2021).

To address this gap in the literature, the objective of this study is to share our learnings from an ongoing CCA project on measuring and reporting disaster resilience changes. It is our hope that these research results will not only contribute meaningfully to academic inquiry into tracking resilience over time, but more importantly, will also have direct, on-the-ground benefits, helping both project implementers and community members to prioritise practical strategies that specifically target areas most likely to enhance their community resilience.

The case presented here is a multi-partner academic and practitioner collaboration pertaining to a CCA project in rural communities in Cambodia. The partners are: Habitat for Humanity Cambodia (Habitat Cambodia), a community development non-profit organisation focusing on housing and other development projects, which works directly with flood-prone communities; and a team of researchers, affiliated with academic and research institutes based in the Global North, bringing a framework, methodology, and additional resources to support the research element of an ongoing project.[1] To measure community flood resilience, we used the Flood Resilience Measurement for Communities (FRMC) approach, developed by the Zurich Flood Resilience Alliance (2019a).

The paper is structured as follows: in the next section, we discuss existing approaches to measuring disaster resilience. In so doing, we highlight our focus on community (village)-level resilience. After introducing our study context in Cambodia in the third section, the fourth section introduces our choice of the FRMC framework, and the fifth section contains an explanation of our data collection methods. The results of the two-step time-series data collection are discussed in the sixth section, indicating changes in community flood resilience over time in the selected communities. The paper closes with suggestions and plans for action. We believe that our work here on measuring community resilience and feeding back the results not only adds to the body of research related to assessing the complexity of resilience, but also contributes to empowering community members to act to improve their resilience.

1.1 | Measuring disaster (flood) resilience

A disaster resilience assessment or measurement is an important endeavour at the science–policy–practice interface (Keating and Hanger-Kopp, 2020). Disaster-centred assessment tools and indices have evolved over the past few decades (Laurien, Martin, and Mehryar, 2022) and the focus of these has ranged from risk (such as the World Risk Index) to vulnerability (such as the Social Vulnerability Index) to, more recently, resilience (typically based on a capacities approach). Resilience assessments may employ a top-down (such as the BRIC (Baseline Resilience Indicators for Communities) model; Cutter et al., 2008) or a bottom-up (such as a resilience scorecard, involving community members) approach. An assessment may be local, regional, national, or international in application, with different purposes. 'Resilience mapping', for instance, may be useful for a comparative assessment of different locations, presenting a snapshot of regional or national rankings and identifying 'hotspots' where more support and interventions are required (see, for example, Mishra et al., 2017; Mavhura and Manyena, 2018; Marzi et al., 2019; Moghadas et al., 2019; Opach et al., 2020; Parsons et al., 2021). If our aim is to support local communities to enhance disaster resilience, and to bring meaningful and context-specific interventions that contribute to workable capacity-building, then understanding deeper contextual conditions is vital. This is more evident when we consider and comprehend resilience as a more systems-based and process-oriented concept, rather than a static situation (Manyena, 2016; Matarrita-Cascante et al., 2017; Laurien, Martin, and Mehryar, 2022).

The definition of disaster resilience put forward by the United Nations Office for Disaster Risk Reduction (UNDRR, 2017, p. 3) is emblematic of more contemporary meanings:

> … [t]he ability of a system, community or society exposed to hazards to resist, absorb, accommodate, adapt to, transform and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions through risk management.

This builds on many earlier studies that conceptualised resilience as a set of capacities and attempted to examine the components that influence resilience (see, for example, Cutter et al., 2008; Twigg, 2009; Cutter, 2016; Sharifi and Yamagata, 2016) and continues in many recent studies (see, for example, Cai et al., 2018; Uddin et al., 2020; Abdul-Rahman et al., 2022; Derakhshan et al., 2022). Kendra, Clay, and Gill (2018), for instance, disaggregate the term 'resilience' into specific elements of 'capitals' or 'capacities' identified in their literature review, which better illustrate the complexities and interrelationships that contribute to building resilience, with emphasis placed on the role of social capital.

Measuring resilience is critical in providing feedback, evidence, and accountability in resilience-building policy, programmes, and investments (Barrett and Headey, 2014; Cutter, 2016) and can help to make what is an intangible and emergent quality of systems more tangible for decision-makers and policymakers (Cutter, 2016). Resilience measurements that are performed periodically can form an important evidence base to track changes in resilience over time (Barrett and Headey, 2014), providing essential information to help steer the process of governance. As Cutter (2016, p. 755) points out: 'Measurement tools cannot create a resilient community, but they can provide directions for becoming safer, stronger, and more vibrant in the face of unanticipated events'.

Attempts at measurement must contend with balancing different objectives, needs, and practicalities (Béné et al., 2017). The multidimensionality of the resilience concept and the emergent nature of the process mean that there is no agreed upon understanding of the key variables that lead to resilient outcomes or which variables should, and can, be measured. A lack of conceptual alignment in definitions and interpretations has led to a lack of consistency across different frameworks, which can erode confidence in measurement credibility for practitioners (Schipper and Langston, 2015; Jones et al., 2021). Inconsistent results can cause confusion among decision-makers trying to understand how to interpret results and where to prioritise interventions (Bakkensen et al., 2017; Jones et al., 2021). Jones et al. (2021) underline the importance of a clear conceptual framework underpinning the measurement approach and robust principles of measurement design. They, and others, also argue for greater use of empirical validation through testing across multiple contexts over time and after a disaster event; a critical step that is still rarely performed (Bakkensen et al., 2017; Jones et al., 2021). Useability is another key consideration: the design of measurement systems must contend with finding a balance between comprehensiveness on the one hand,

and manageability in terms of the number of indicators and data collection burden on the other—that is, it should be short enough to be useable but comprehensive enough to make it useful.

Some of the more well-known resilience frameworks that are based on a capacities approach (and earlier applied studies on CDR introducing and/or applying these frameworks) include BRIC (Cutter, Burton, and Emrich, 2010), Community Based Resilience Analysis (UNDP, 2017), the Disaster Resilience of Place model (Cutter et al., 2008; Mavhura, Manyangadze, and Aryal, 2021), the Disaster Resilience Scorecard for Cities (UNDRR, 2017), the PEOPLES resilience framework (Cimellaro et al., 2016), and the Disaster Resilience Integrated Framework for Transformation (Manyena, Machingura, and O'Keefe, 2019).[2] In addition to the multidimensional framing of resilience based on capacities or capitals, many frameworks and measurement approaches either explicitly or implicitly start from the assumption that resilience strengthening involves employing these capacities to enhance absorptive, adaptive, and transformative strategies to reduce the system's exposure and vulnerability to natural hazards (Cutter et al., 2008; Béné et al., 2017).

While multidimensional framings of community resilience are becoming more common (see, for example, Marzi et al., 2019; Mendonça, Amorim, and Kagohara, 2019; Moradi, Nabi Bidhendi, and Safavi, 2021; Oriangi et al., 2021; Marasco, Kammouh, and Cimellaro, 2022; McConkey and Larson, 2022), there are of course many ways to define the multiple elements that constitute a complex system. The framework of resilience that we opted for (as explained further in the following section) is based on five common capitals, namely, human, social, physical, natural, and financial, but these are sometimes complemented by a sixth (or more) dimension: institutional (see, for example, Parsons et al., 2021; Payne et al., 2021), political (see, for example, Miles, 2015), or sometimes governance.

1.2 | Case study context

Cambodia is considered to be a country highly vulnerable to climate change. Fluctuating rainfall patterns and rising temperatures and sea level will lead to increased flooding, drought, and storms that are expected to reduce productivity in agriculture, fishing, and forestry, as well as decrease labour productivity across most sectors. Cambodia is already highly vulnerable to disasters, with regular monsoon flooding in the Mekong and Tonlé Sap basins. Floods, either flash floods or slow-onset floods,[3] have been identified as the most damaging type of disaster, as they affect the largest number of people and the most extensive area as compared to other hazards, while having the most significant economic impacts in terms of damage and losses. Battambang is one of the most flood-affected provinces in the country. According to the latest data available from the Cambodian National Committee for Disaster Management, in 2022 alone, Battambang experienced flash floods and river floods that affected 18,786 households and 66,641 people (Cambodia Humanitarian Response Forum, 2022). The project site for our research is located in Preak Luong commune, Ak Phnom district, Battambang province.

In early 2021, Habitat Cambodia began implementing a CCA project titled 'Enhancement of Climate Change Resilience and Income of Preak Luong Community People in Cambodia', with funding support from the Community Chest of Korea through Habitat Korea, targeting all seven villages located along the Sangker River within the commune. According to Habitat Cambodia's internal survey at the beginning of the project, there has been a notable increase in the number of reported incidents encountered by households, especially in the previous five years; the annual proportion of flood-affected households rose from only about 10 per cent in 2016 to nearly 40 per cent in 2020 (Sopheak and Vireak, 2021). While heatwaves and drought have also become serious concerns recently (especially drought, with the number of affected households reportedly increasing from zero in 2014 to more than 57 per cent in 2019), flood and strong winds have been steady concerns, being reported every year for the past decade. The three-year CCA project, called the 'CCK project' after the Korean sponsor, aims to enhance community resilience to climate change by focusing on three main activities centred on safe and flood-resilient housing:

- climate-resilient housebuilding, through mentoring and coaching in retrofitting housing, home maintenance, and basic construction techniques;
- additional income-generating activities via climate change-adapted home gardening, and the introduction of a system using ‘middlemen’, who buy crops from homeowners; and
- capacity-building for climate adaptation through the Commune Committee for Disaster Management (CCDM) and training of CCDM members in climate change and disaster management.

2 | METHOD: FLOOD RESILIENCE MEASUREMENT FOR COMMUNITIES

Resilience is a multi-scalar and nested notion; that is, it exists at multiple levels, such as the individual, community, and organisation level, or sometimes even refers to an entire country (Buikstra et al., 2010; Wilson, 2012; Matarrita-Cascante et al., 2017). In other words, resilience can be understood and investigated at different levels, but our emphasis here is on the complex sets of relations at the *community* (village) level.[4]

For the purposes of this project, we adopted and applied the FRMC, developed, as noted, by the Zurich Flood Resilience Alliance (2019a, 2019b; see also Keating et al., 2017a, 2017b). This was partly because of its emphasis and focus on flooding, but more importantly because of its holistic, systems-based capacities model, as well as experience of the framework within the research team. This model allows us to collect and examine multiple time-series and comparable data across different communities.

The FRMC is, to our knowledge, the most widely applied standardised community disaster resilience measurement framework in the world, having been applied in approximately 400 communities across 29 countries over 10 years. It was developed specifically to inform community flood resilience strengthening projects such as this one (Keating et al., 2017b). The FRMC has to date primarily been used in rural communities in developing country contexts, further contributing to its validity for use in this project. As described in Laurien and Keating (2019) and Keating (2020), while the community flood resilience strengthening projects that are informed by the FRMC are highly varied, they have in common the features of aiming to tackle underlying drivers of risk and having benefits across multiple resilience domains.

The FRMC approach comprises a multidimensional capitals-based framework for understanding and assessing community flood resilience, and a hybrid (web- and mobile-based) software application for applying the framework in practice. The conceptualisation of community disaster resilience underpinning the FRMC is based on social-ecological systems thinking; community disaster resilience is the ‘ability of a community to pursue its development and growth objectives, while managing its flood risk over time in a mutually reinforcing way’ (Keating et al., 2017b). The FRMC consists of 44 indicators, called ‘sources of resilience’, across five complementary ‘capitals’[5]:

- human capital: education, skills, and health;
- social capital: social relationships and networks, bonds that promote cooperation, links facilitating exchange of and access to ideas and resources, as well as institutional or governance arrangements;
- physical capital: things produced by economic activity from other capital, such as infrastructure and equipment;
- natural capital: natural resource base, including land productivity and actions to sustain it, as well as water and other resources that sustain livelihoods; and
- financial capital: level, variability, and diversity of income sources and access to other financial resources that contribute to wealth.

Instead of considering these dimensions in isolation—such as looking at a specific sector like the health system or transport network—they are considered together, in an integrated manner. In this way, the FRMC supports users and communities in seeing beyond immediate issues and understanding the complex drivers of both risk and development outcomes (Keating et al., 2017b; Zurich Flood Resilience Alliance, 2019b). The framework, therefore, paints

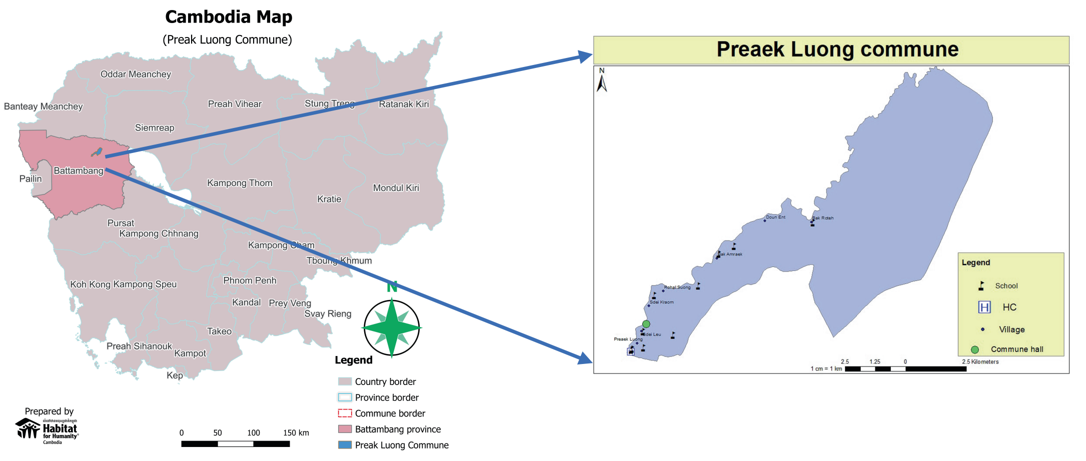

FIGURE 1 Map showing villages in the CCK project, Preaek Luong commune, Battambang province, Cambodia. **Source:** authors, developed by Habitat Cambodia using the QGIS desktop system.

a holistic picture of the community's capacities. Each source of resilience (indicator) within the framework includes a definition, questions for various data collection methods, and a standardised rubric for assessing data in order to assign a 'grade' from A (best practice) to D (significantly below good standard). A full list of the sources of resilience is provided in Table A1 in the Appendix.

Data to inform the grading of each source of resilience can be collected via household surveys, key informant interviews, focus-group discussions, or the use of available secondary source information. Users select the data collection methods for each source of resilience with respect to their particular context and preferences. Following data collection using the smartphone- or tablet-based app, data are automatically uploaded to the web application. From here, trained assessors grade each of the 44 sources of resilience from A–D. Once the grading process is complete, the results are explored via the data cockpit, with the functionality to explore and analyse results according to the five capitals as well as other aggregations or 'lenses'—for an overview of the FRMC process, see Zurich Flood Resilience Alliance (2019a, 2019b).

2.1 | Data

From the total of seven villages in the commune benefiting from the CCK project, three were selected based on geographical proximity and socio-demographic similarity (such as similar size of the village and relatively higher poverty rates) for our research project of time-series measurements of CDR: Bak Amraek (BA); Bak Roteh (BR); and Doun Ent (DE) (as highlighted in Table 1). The similar socioeconomic conditions in the three villages are deliberate, to avoid any potential bias in differences in outcomes (changes over time determined by comparing the first and the final year measurement of the CDR of the three villages).

Tables 2a and 2b summarise the number of participants in our data collection in February 2022 (T0), and again in February 2023 (T1), involving in-person household surveys and focus-group discussions as well as key informant interviews, as part of the FRMC methodology described above.

2.2 | Time-series resilience changes by village and by five capitals

We now present the findings from the two-year time-series data collected at the baseline (T0) and one year later (T1) in the three villages. It is critical to note that these results are presented for analytical purposes only and are not

TABLE 1 Preak Luong commune and the CCK project's beneficiary villages.

		Population			Poor families			Vulnerable people		
					ID	ID				
Village	Number of households	Total	Female	Percentage female	Poor 1*	Poor 2*	Percentage poor	Disability	Elderly	Percentage vulnerable
Preak Luong	522	2,187	1,215	55.6	12	53	3.0	17	240	11.8
Sdei Leu	426	1,736	907	52.2	36	52	5.1	24	191	12.4
Sdei Kraom	353	1,441	747	51.8	65	35	6.9	24	158	12.6
Rohal Suong	395	1,572	854	54.3	38	71	6.9	29	172	12.8
Bam Amraek	252	1,334	695	52.1	61	48	8.2	24	146	12.7
Doun Ent	255	1,089	503	46.2	77	28	9.6	27	120	13.5
Bak Roteh	267	1,254	625	49.8	36	68	8.3	9	138	11.7
Total	2,470	10,613	5,546	52.3	325	355	6.4	154	1,165	12.4

Note: ID Poor 1 ('very poor') and ID Poor 2 ('poor') refer to the poor families that earn less than USD 1.67 per day and hold the equity cards issued by the government.
Source: commune data, as provided by Habitat Cambodia in September 2021; villages ordered from upstream to downstream.

TABLE 2a FRMC household survey participants (yearly).

Village	Number of households	Sample size (households)
Bak Amraek	252	100
Bak Roteh	267	100
Doun Ent	255	100

Note: the confidence level is 95 per cent; the interval of household data gathering at 2.5.
Source: authors.

TABLE 2b FRMC focus-group discussions and key informant interviews.

	Data collection (yearly)								
	Focus-group discussions					Key informant interviews			
Village	General community group	Women's group	Disabled persons' group	Elderly persons' group	CCDM members	CCDM head	Health official	Village head	School director
Bak Amraek	2	2	1	1	1	1	1	1	2
Bak Roteh	2	2	1	1				1	1
Doun Ent	2	2	1	1				1	1

Source: authors.

designed to compare the villages with each other. The FRMC provides a snapshot of a community's flood resilience at one point in time and by its nature, cannot capture all of the myriad of complexities that make up a community system. As the three communities in this study are close to each other and have similar geographies and socioeconomic conditions, as described above, highlighting relative strengths and weaknesses can be a source of insight for designing resilience strengthening initiatives.

2.2.1 | Baseline findings

Analysis of the average weighted scores of the three villages across the five capitals reveals that all three villages have similar levels of financial and social capital, which accords with the socioeconomic descriptions presented above. These scores place financial and social capital at an overall C grade. In contrast to the other two villages, BA has a higher human capital score, potentially indicating a strength that could be leveraged and/or a potential for acceleration in this area. At the same time, BA has the lowest capital score across the studies: 33 for natural capital. This capital-level analysis indicates a potential area of urgent need in relation to ecosystem health and environmental sustainability in BA. Meanwhile, physical capital in DE stands out as stronger, compared to the other two communities. While the villages present a largely homogenous profile, Figure 2 highlights slight differences in terms of strengths and weaknesses across the dimensions in the villages.

As explained above, grades ranging from A to D were accorded to each source of resilience. Figure 2 summarises the proportion of sources of resilience within each capital that were given each of the grades. The results in the financial capital domain confirm the high poverty rates in the communities and affirm action around income generation, particularly initiatives that can provide livelihood diversification. Given that the three communities are all agricultural and practice relatively non-intensive asset construction, the low grades for natural capital may indicate a need for river-scale environmental sustainability improvements. Relatedly, the physical capital results are spread across the grades, indicating strengths in some areas and weaknesses in others—further in-depth analysis may

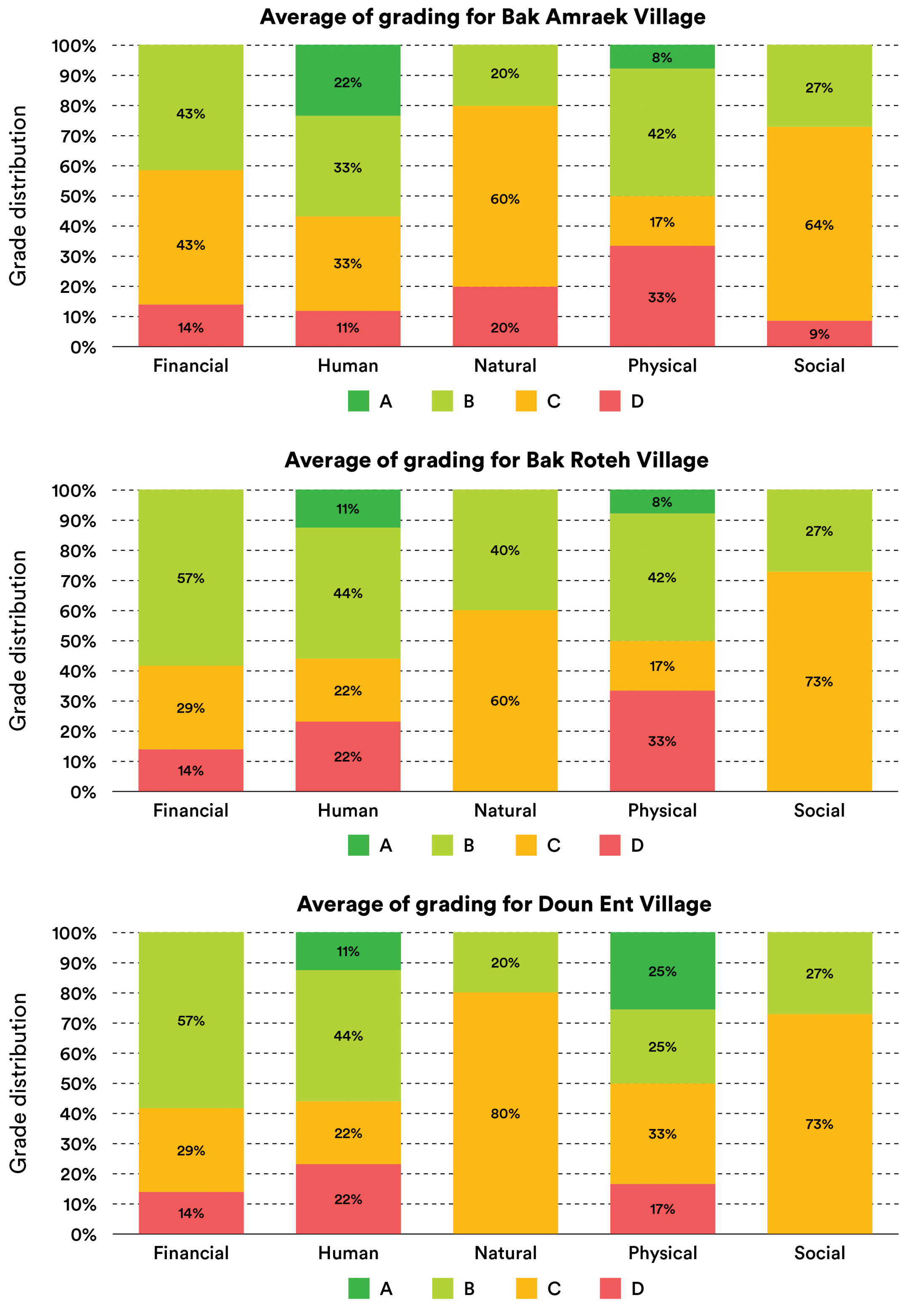

FIGURE 2 Baseline FRMC data results by village. **Source:** authors.

highlight the dynamics here. Human capital (with more sources being graded as A) is identified as a relative strength in BA, while DE appears to have some relative strength in the area of physical capital. Lastly, social capital is fairly weak across the three communities. This is likely driven by the fact that social capital sources of resilience include a focus on governance and bridging and linking social capital, which affirms work to strengthen CCDM capacities. At the same time, it also highlights the need to build village-level disaster risk management practices.

2.2.2 | Resilience changes over the project period

Now we turn to the two-year time-series changes (see Figures 3a–3c).

Overall, the changes are similar across the three villages. First, and particularly noteworthy, is the improvement in the human and social dimensions of resilience—the average weighted score in human capital, for example, increased from 55 to 63, 48 to 55, and 48 to 66, in BA, BR, and DE, respectively, with DE recording a huge leap in these areas. The human capital group of FRMC resilience sources includes variables like evacuation and safety knowledge, first aid knowledge, education commitment during floods, and environmental management awareness. This improvement can be attributed to the effects of training, as provided as part of the CCK project, and as an additional support as part of our research project.

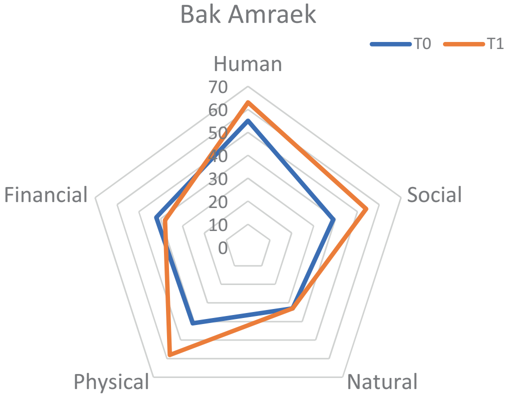

FIGURE 3a Resilience changes from T0–T1: BA. **Source:** authors.

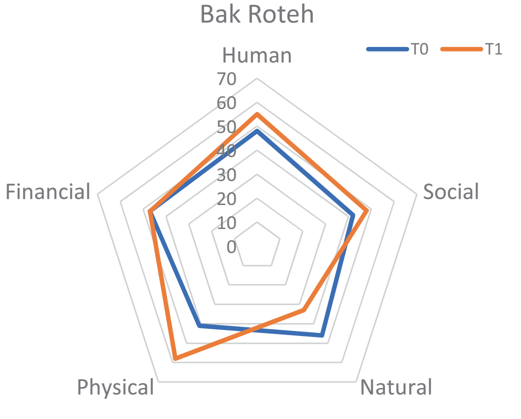

FIGURE 3b Resilience changes from T0–T1: BR. **Source:** authors.

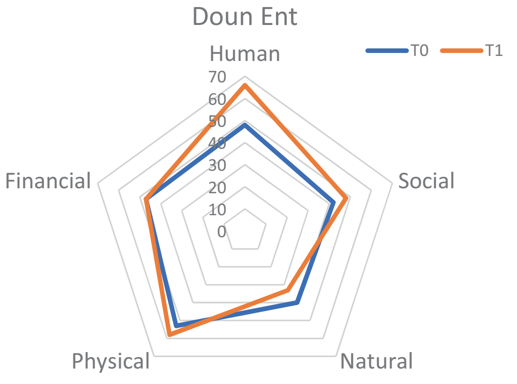

FIGURE 3c Resilience changes from T0–T1: DE. **Source:** authors.

Social capital also shows a noticeable improvement, from 39 to 54 in BA and 42 to 48 in both BR and DE. Social capital resilience includes such sources as community participation in flood-related activities, community disaster risk management planning, and inter-community flood coordination. All of these have likely improved owing to CCK support in activating and strengthening the CCDM, via support and training of its members.

We found noticeable improvement in physical capital for BA and BR, while a lesser change was detected in DE (the initial status of which was already relatively better than in its two neighbouring villages). Improvements in transportation and communication interruption during floods are understood to be due to overall development taking place in the region. This also applies to improvements in access to safe water and the supply of energy during floods. The project implementers (Habitat Cambodia) noted an overall improvement in the early warning system because of government initiatives to enhance disaster preparedness. In sum, most improvements made in the physical capital dimension are attributable to external enabling environmental effects rather than project effects per se.

The results from the natural capital indicators require careful interpretation. The FRMC national capital group consists of five sources: natural capital condition; natural resource conservation; national habitat restoration; priority natural units; and priority managed units. Owing to these three villages being located in close proximity to each other (within approximately three kilometres), they fall under the same administrative unit of the commune. This physical and administrative closeness means that any conservation and restoration of natural conditions, as well as initiatives to manage ecosystems and natural resources, are the municipal government's responsibility and are not prioritised in non-governmental organisations' activities. The actual situation of natural capital, therefore, by virtue of non-interference, either remained stable, or in BR's case, declined substantially.[6]

Our results show a relatively stagnant status in the financial capital domain, despite enhancing financial resilience being a priority for the project, which has promoted additional income-generating activities such as climate change-adapted home gardening. Unavoidable project limitations resulted in the number of beneficiaries of the new homes and gardening fields being smaller than anticipated; a reality of undertaking community development projects. Meanwhile, the particular decline in BA is explained by increasingly limited access to microfinance in the post-COVID-19 (Coronavirus disease 2019) era—community practitioners from Habitat Cambodia confirmed that the more generous access to microfinance during the COVID-19 period was withdrawn as government COVID-19 support programmes were wound down. This is an interesting issue that requires further analysis, but it is beyond the scope of the current study.

3 | DISCUSSION

By examining changes in the subdimensions of resilience over the course of one year during project implementation, we found that the CCK project successfully contributed to improving the resilience dimensions of human and social capital;

evidence from both measurement and fieldwork demonstrates that this is largely attributable to the successful training provided by the project. In other words, CCA capacity-building—the third objective of the project—was found to be successful.

In particular, the CCK project unarguably contributed to enhancing social capital in the three villages, notably by activating the disaster management committee at the commune level. Prior to this project, the CCDM existed in structure as recommended by the government, however the Habitat Cambodia project implementing team reports that its actual functions were only activated owing to CCK project support. This delivers a mixed message. On the one hand, this is a positive message about the project's effectiveness, but on the other hand, it raises questions about the sustainability of outcomes: will the CCDM remain active after the end of the aid-supported project? This remains to be seen.

Although we identified overall improvement in physical capital as well, we did not find robust evidence that this is due to the project. While housing provision was put forward as a key priority for the project and is where the implementing organisation's expertise lies, because of contextual limitations to date, housing provision has been limited to a few selected families, rendering project effectiveness in this area undetectable as yet. The resilience sources within the physical capital group also go far beyond household flood protection; in fact, we found more improvement in other areas, such as declines in transportation and communication interruptions during floods and the like. This is more attributable to overall development in the region, rather than to the project itself.

Any effects in the financial capital dimension remain negligible. Similarly, actions in the national capital domain were not prioritised, which is reflected in the results. To strengthen these areas, further targeted strategies and more engagement with responsible stakeholders (in particular governments), via and/or beyond the CCDM, are recommended.

The use of a disaster resilience measurement framework in the context of this project highlights both the value and limitations of the measurement endeavour. Overall, we found that measuring CDR in the setting of a rural community development project is both possible and useful. Systematic data collection and analysis across the multiple dimensions of resilience (as reflected in the literature) did indeed bring a level of systems-based understanding to both the implementing partner organisation and the community members themselves.

The generation of robust evidence of enhancement in human and social capital as a result of the project demonstrates the value of CDR measurement for user organisations. Findings regarding limited change in financial capital serve as an important insight into the complexities of delivering resilience strengthening projects on the ground, for both practitioners and researchers alike. Lastly, findings concerning physical and natural capital contexts underscore the importance of a system-wide analysis of CDR, beyond the focus of a particular project. Identifying both deficits and improvements in CDR outside of the implementing organisation's project leads to key learning highlighting the importance of local collaborations among stakeholders, particularly governments at the local and provincial level. Indeed, large-scale (cross-village level) infrastructure initiatives, conservation and restoration of ecosystem services in the watershed, and systemic governance issues such as early warning, can only be addressed by the government and are beyond the individual village level.

4 | CONCLUDING REMARKS

The main objective of this applied study was to examine changes in disaster resilience in three village communities in Battambang, Cambodia, over the course of the CCK project. This study neither intended nor expected to be a representative study of Cambodia. Rather, it provides a case study exploration of the multidimensional conceptualisation of flood resilience in the selected villages. We have shown the practical utility of applying such a framework in the communities concerned. As presented in this paper, a multidimensional approach can serve as a meaningful avenue to understand the holistic, systems-based nature of resilience. Furthermore, we found that the use of data visualisation can identify areas of strength and weakness in resilience—expressed by different sources of resilience (or groups of sources)—to inform potential interventions.

By applying this community flood resilience measurement approach, we generated empirical evidence to support the continuation of the CCK project. The project was enhanced by the fact that this approach facilitated deep, contextually-specific understanding of the best entry points for strengthening CDR, which were then further reflected in continued follow-up activities in the villages. We discovered that one of the most critical benefits of applying a multidimensional and holistic framework of resilience—rather than examining and evaluating any project according to its own set objectives—is that it draws attention to critical areas that may have otherwise been overlooked for various reasons, such as limited budgets and a lack of expertise, experience, and capacity. In sum, we have provided evidence-based and context-specific policy suggestions to enhance CDR, which have the potential to contribute to resilient community development in the region. The practical utility of applying this framework is particularly salient considering that resilience is a complex concept that cannot be expressed in a single number, but instead needs to be examined multidimensionally.

The limits of our application of the FRMC, however, must also be acknowledged. The FRMC is designed to facilitate active community participation and initiatives on disaster risk reduction/CCA throughout the process. Our conclusion from the field observation, though, is that this ideal has yet to be attained.[7] The journey towards genuinely *community-led* disaster resilience strengthening is a long one; currently, the communities involved in this study remain heavily dependent on external financial aid and decision-making (ranging from beneficiary selection to the types of intervention). This is not a critique of the communities themselves or the implementing non-governmental organisation, but rather a reflection of the multitude of challenges faced in striving for this best practice community development. More in-depth study is required in the future with regard to the capacities of various stakeholders and governance issues in general, particularly related to the natural capital dimension.

It is our hope that ongoing community flood resilience strengthening project work, together with participation in this research, may incentivise and enhance community members' capacity, trust, and willingness to participate. Best practice community development work puts communities in the vanguard, with practitioners and researchers playing a supporting role. Challenges of engagement and participation of community members are also important issues worthy of lengthy discussion, which we intend to turn to in a follow-up study.

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Chantra Sourn is currently affiliated with Habitat Cambodia, the project implementer. He provided contextual background and information on the CCK project as described in the third section. The data analysis and discussion, however, are mainly by the other two authors and Chantra Sourn's input does not alter the findings and conclusions.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.[8]

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ENDNOTES

[1] It should be noted that the research team and the project team are two different bodies, and that the researchers did not have any influence on the project activities that had been determined before the research component was added to the pre-planned project. Ideally, synchronising the research and the project from the beginning could have led to the proposal of different activities and interventions.

[2] For a deeper discussion of the strengths and limitations of each existing framework, see, for example: Manyena, Machingura, and O'Keefe, 2019; Mavhura, Manyangadze, and Aryal, 2021; Laurien, Martin, and Mehryar, 2022.

[3] Slow-onset flooding can occur slowly as rain continues to fall for many days. It can take a week to develop and can last for months (before floodwaters recede).

[4] We acknowledge the ambiguity and debate regarding the conceptualisation of community (see, for example, Kruse et al., 2017; Titz, Cannon, and Krüger, 2018), but it is not possible to go into an in-depth discussion of it here owing to limited space. Instead, we use *community* in this paper mostly to refer to a village, unless noted otherwise, as villagers referred to the village as their *community* when talking about CCA.

[5] The conceptualisations of the five capitals that underpin the FRMC are adapted from DFID (1999) and Nelson, Adger, and Brown (2007). Further information can be provided upon request.

[6] Based on a field observation by Habitat Cambodia. Over the course of the project, it was revealed that our T0 grading must have been too generous for BR, which was corrected at T1; but we could not correct the original T0 grade once it had been inputted into the system.

[7] This is mainly drawn from the lead researcher's qualitative inquiries, which could not be included in the present paper owing to space; they will be addressed elsewhere.

[8] The data are not publicly available owing to limited technical access to the FRMC data repository.

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APPENDIX A

TABLE A1 FRMC sources of resilience.

Human capital
Evacuation and safety knowledge
First aid knowledge
Education commitment during floods
Flood exposure awareness
Asset protection knowledge
Future flood risk awareness
Water and sanitation awareness
Environmental management awareness
Governance awareness
Social capital
Community participation in flood-related activities
External flood response and recovery services
Community safety
Community disaster risk management planning
Community structures for mutual assistance
Community representative bodies
Social inclusiveness
Local leadership
Inter-community flood coordination
Integrated flood management planning
National forecasting policy and plan
Physical capital
Flood healthcare access
Early warning systems
Flood emergency infrastructure
Provision of education
Household flood protection
Large-scale flood protection
Transportation interruption
Communication interruption
Flood emergency food supply
Flood safe water
Flood waste contamination
Flood energy supply
Natural capital
Natural capital condition
Priority natural units
Priority managed units
Natural resource conservation
Natural habitat restoration

(Continues)

TABLE A1 (Continued)

Financial capital
Household asset recovery
Community disaster fund
Business continuity
Household income continuity strategy
Risk reduction investments
Disaster response budget
Conservation budget

Source: authors, based on FRMC training materials on overview over the 44 sources of resilience.