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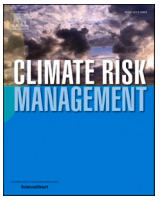

# Multiple resilience dividends at the community level: A comparative study of disaster risk reduction interventions in different countries

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ABSTRACT

Climate-related disasters are increasing in many parts of the world, yet investment in disaster risk reduction (DRR) remains insufficient to manage these risks. This is despite growing recognition that DRR interventions can reduce potential impacts from disasters as well as deliver broader economic, ecological, and social co-benefits. Focusing on the net benefits of DRR, beyond avoiding losses and damages, is considered as an important strategy to strengthen the case for DRR as part of a sustainable development by academics and international organizations alike. However, there is very limited evidence of on-the-ground accounting of these "multiple resilience dividends" by those who act to reduce disaster risk at the local level. Using an innovative analytical approach, we investigate the knowledge gaps and challenges associated with considering multiple resilience dividends in the planning, implementation, and evaluation of DRR interventions at the community level for the example of flood risk. We use a newly developed framework to analyze empirical survey data on community-level DRR interventions as well as five in-depth case studies from Vietnam, Nepal, Indonesia, Afghanistan, and the United Kingdom. The analysis reveals a disconnect between available planning tools and the evidence of materialized multiple resilience dividends, which is a key obstacle to successfully apply the concept at the community level. Structured consideration of multiple resilience dividends from the planning to the monitoring and evaluation stages is required to secure local buy-in and to ensure that these dividends materialize as intended.

## 1. Introduction

Climate-related disasters have caused USD $2.2 trillion in losses and damages since 2000 and have affected approximately 3.9 billion people globally (Guha-Sapir et al.). A special report by the Intergovernmental Panel on Climate Change (IPCC) on 1.5 °C global warming showed that each half degree of global warming increases the magnitude of climate-related hazards, with disadvantaged and vulnerable populations being at disproportionally higher risk (IPCC, 2018). In addition, socioeconomic trends such as the increasing

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number of at risk assets are expected to increase disaster risk even further across many parts of the world, leading to more losses and damages in the future if no action is taken (Bouwer 2019, Formetta and Feyen, 2019). In many regions, especially in the developing world, disasters have considerable short- and long-term implications, such as severe disruptions to economic development and livelihood (Shabnam, 2014, Davis and Alexander, 2015), severe fiscal stress (Hochrainer-Stigler et al., 2014), worsening levels of poverty (Hallegatte and Rozenberg, 2017), and increasing government debt (Koetsier, 2017). To reduce or even avoid these negative consequences, the 2015 World Conference on Disaster Risk Reduction in Sendai, Japan, defined investment in disaster risk reduction (DRR) for resilience as one of four priority action areas over the next 15 years (Priority area 3) (UN, 2015). This marks a paradigm shift from managing disasters to reducing disaster risk and building resilience, which has led to an increase in investments in ex-ante DRR over the past years (UN, 1994; UN, 2015; Imperiale & Vanclay,2021). However, ex-ante investments are still dwarfed by ex-post spending on emergency response and recovery (Kellet and Caravani, 2013). Despite the growing evidence that proactive risk reduction is paying off (Shreve and Kelman, 2014, Mechler, 2016, MMC, 2019), the uncertainty of whether a disaster will happen over the lifetime of a DRR intervention and whether the intervention will successfully prevent a disaster often makes ex-ante investments in DRR unattractive for donors and decision makers faced with budget constraints (Tanner et al., 2015, Wright, 2016, Fraser et al., 2020).

However, there is growing recognition that DRR not only helps to save lives and reduce losses and damages but has wider benefits which can play an important role in supporting the sustainable economic development of communities. Those frequently overlooked additional benefits of investments in DRR such as attracting businesses due to the lower disaster risk in an area or ecosystem services from nature based DRR solutions have been summarized and framed in the literature under the term "resilience dividends" (Rodin, 2014, Tanner et al., 2015, Vorhies and Wilkinson 2016, Surminski and Tanner 2016). Since many of those resilience dividends materialize independent of a disaster event happening, they are seen as a promising way to create a broader business case for increasing the popularity of pre-event investments in DRR (GCA, 2019).

Although the "multiple resilience dividends", described as the sum of the net benefits materializing in the absence and those materializing in case of a disaster, are an attractive proposition on paper, there is still limited evidence from applying the concept on the ground. The first examples of DRR interventions based on a dedicated multiple resilience dividend approach are starting to emerge, for example under the triple dividend of resilience (TDR) concept advocated by the World Bank and others, but challenges in considering these multiple resilience dividends in the planning, implementation, and monitoring and evaluation of DRR interventions remain. The TDR uses three categories to structure the multiple resilience dividends associated with investments in DRR: *avoiding losses and damages (1st dividend)*, *unlocking economic potential (2nd dividend)* and *additional co-benefits (3rd dividend)* (e.g., Tanner et al., 2015, Surminski and Tanner 2016, GCA, 2019).

Combining the structured approach of the TDR (Tanner et al. 2015) with the DRR project cycle (Brent, 1998) we develop a new analytical framework to analyze survey data and case studies from community-level DRR interventions. This allows us to identify the barriers and challenges in including multiple resilience dividends at each stage of the DRR interventions' life cycle. This includes an analysis of how monitoring and evaluating multiple resilience dividends of DRR interventions can inform the planning of future interventions. Our analysis uses the example of flood risk as the most common and widespread climate related disaster risk, with an estimated 1.49bn people (19% of the world's population) directly exposed to flooding globally (Rentschler & Salhab, 2020). The analysis covers 12 countries, including the analysis of survey data of community-level DRR interventions in Mexico, El Salvador, Nicaragua, Peru, Montenegro, Bangladesh, Nepal and the Philippines as well as in-depth case studies from the UK, Afghanistan, Nepal, Vietnam and Indonesia. We find that the majority of interventions were planned and implemented to deliver at least one additional resilience dividend, but a number of challenges and barriers were reported in terms of systematically recording and quantifying those resilience dividends. The case study analysis revealed that existing monitoring and evaluation approaches can lead to intended and unintended resilience dividends going unnoticed after the implementation of a DRR intervention, ultimately failing to contribute to the still scarce evidence base on quantified multiple resilience dividends needed during the planning and appraisal stage of a DRR intervention. To overcome some of the identified challenges, we discuss that a structured consideration of multiple resilience dividends during planning and appraisal as well as quantification after their successful materialization are necessary to overcome the skepticism of local decision makers toward this approach, which was identified as a key barrier. We propose an integrated decision-making framework that allows the systematic inclusion of individual resilience dividends at each stage of the decision-making process for DRR interventions.

## 2. Decision making for DRR interventions and multiple resilience dividends

### *2.1. DRR interventions and multiple resilience dividends*

DRR interventions include a range of actions and measures that aim to reduce the harmful impacts of disasters while increasing the resilience and overall well-being of communities faced with such disasters and is the outcome of an investment in DRR (IOM, 2020). DRR interventions can be either structural (e.g., levees to reduce the risk of flooding) or non-structural (e.g., changes in agricultural practices).

The concept of multiple resilience dividends is rooted in community disaster resilience, which can be defined as the ability of communities on a system level to withstand, adapt to, and recover from shocks (such as a flood event) in a way that it enables them to pursue their social, ecological, and economic development objectives (Davidson et al., 2016, Keating et al. 2017). By understanding disaster resilience as "bouncing forward" (instead of previous definitions as "bouncing back"), the multiple resilience dividends make a direct link between previous views on the net benefit of investments in DRR interventions as the reduction of losses and damages and the wider benefits that actively support sustainable economic development in disaster-prone communities. Fung and Helgeson (2017)

define the latter as the net benefits of a DRR intervention in the absence of a disastrous event. Importantly, some DRR interventions are expected to create larger resilience dividends than others (Mechler & Hochrainer-Stigler, 2019). Those "additional" resilience dividends (i.e. materialized in absence of a disaster) can be either unintended side effects of the implementation of a DRR intervention (e.g., the emergence of a tourism industry from a reservoir originally designed for flood and drought management) or can be intentionally included in the appraisal and planning of the intervention (e.g., a tsunami shelter that is designed to double as a community center; Fung and Helgeson, 2017). Both intended and unintended additional resilience dividends of DRR interventions are considered in this study (see Fig. 1). Together with the resilience dividend that materializes in the case of a disastrous event they form the multiple resilience dividends of DRR interventions. By looking at examples of both intended and unintended resilience dividends in this paper, we discuss how multiple resilience dividends in DRR interventions materialize at the community level, how it can benefit its development and how they can be recorded and structured to support the evidence base when planning future projects.

### 2.2. *Linking the evidence base on materialized multiple resilience dividends to appraisal tools and frameworks*

The literature on multiple resilience dividends of DRR interventions is sparse and fragmented. Two strands of literature have evolved over the years. The first includes case studies in both the academic and gray literatures reporting empirical or anecdotal evidence of multiple resilience dividends of DRR interventions, often in the context of co-benefits of ecosystem-based adaptation (EbA) and nature-based solutions (NbS) (McVittie et al., 2018, Tomczyk et al., 2016, Helgeson and O'Fallon, 2021). The second strand of literature describes tools and approaches for a structured consideration of multiple resilience dividends in the planning and appraisal of DRR interventions (Fung and Helgeson, 2017, Fung et al., 2020). The latter includes variations of multicriteria analysis (MCA) (Wardekker et al., 2016, Scrieciu et al., 2014), extensions of cost-benefits analysis (CBAs) to include social welfare implications (Herrero and Ürge-Vorsat, 2013), as well as pathway analyses that estimate the multiple resilience dividends of an intervention over time compared to a baseline scenario (Craig et al., 2017).

The reported evidence of multiple resilience dividends varies considerably between studies. The majority of studies either just mention additional resilience dividends in the context of a DRR intervention or describe them qualitatively without further considering them (e.g. as part of the planning process and/or the monitoring and evaluation of an intervention; Vorhies and Wilkinson, 2016, Surminski and Tanner 2016, Tanner et al., 2015, Helgeson and O'Fallon, 2021). A smaller group of studies considers multiple

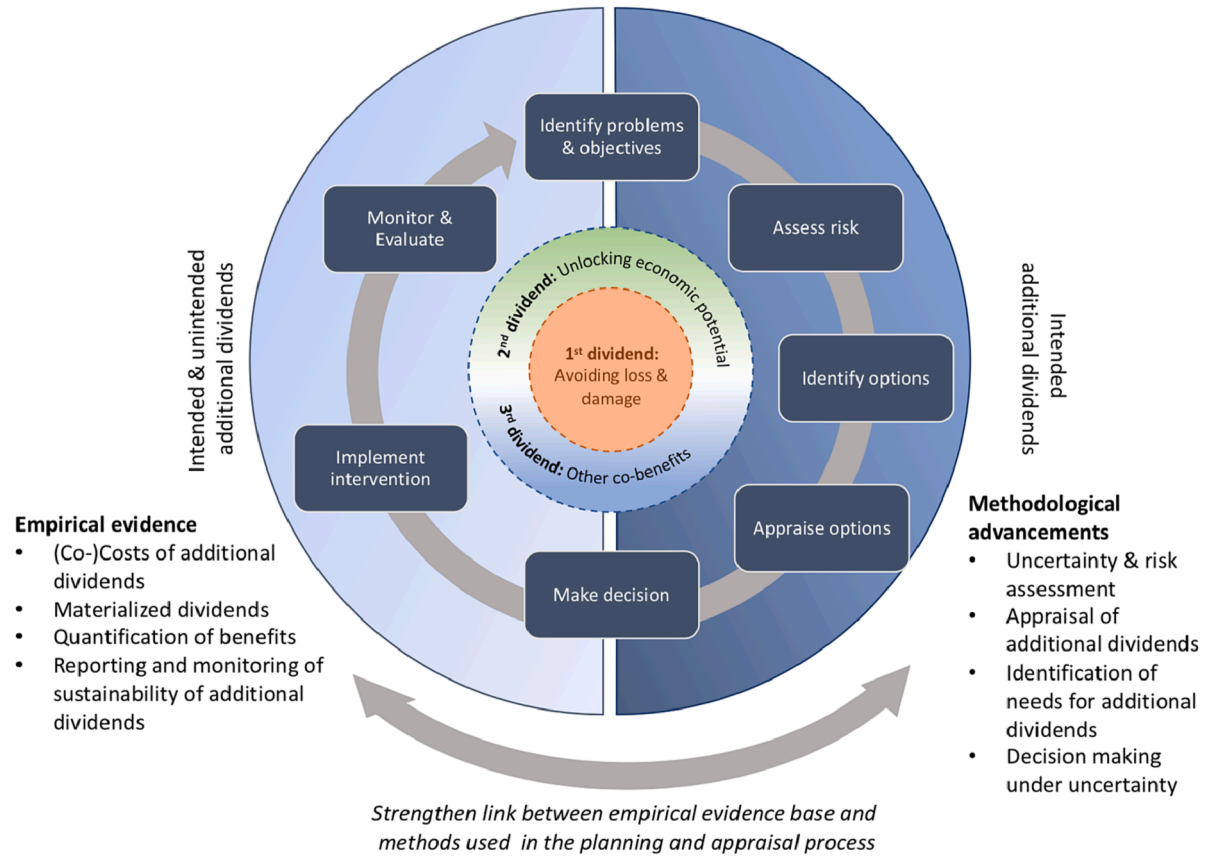


**Fig. 1.** Integrated framework for considering resilience dividends throughout the life cycle of disaster risk reduction interventions based on Tanner et al. (2015), Brent (1998), and Mechler (2016).

resilience dividends in the planning process, including formal appraisals mostly based on assumptions due to lacking empirical evidence and data on expected benefits (Craig et al., 2017, Fung et al., 2020). Only a few studies, use quantified empirical evidence of multiple resilience dividends of DRR interventions either as part of ex-ante appraisals (using the scarce quantitative evidence reported in the literature) or by quantifying resilience dividends as part of ex-post evaluations of implemented interventions (Fung and Helgeson, 2017, Mechler and Hochrainer-Stigler, 2019, Heubaum et al., 2022).

Especially studies with quantified empirical evidence of multiple resilience dividends of DRR interventions are increasingly demanded by scholars, practitioners, and donor organizations, as it is key to both substantiating the high-level narrative of multiple resilience dividends for advocacy purposes as well as informing the design of DRR interventions on the ground (Heubaum et al., 2022). However, quantified evidence of materialized multiple resilience dividends of DRR interventions currently lag behind their underlying concepts and narratives.

One reason for the lack of such evidence has been linked to the different time frames over which different resilience dividends can materialize (Reyers et al., 2015). Whereas some dividends materialize almost immediately after an intervention has been implemented and can be measured and quantified shortly thereafter (e.g., weather forecasting systems to improve early warning and farming practices), others can take years (e.g., the restoration of mangrove forests) or decades (e.g., stopping or reversing outmigration from disaster-prone communities) to become evident. These long-time frames make it difficult to obtain empirical evidence of the full range of resilience dividends of DRR interventions, as doing so requires conducting ex-post evaluations decades after the implementation of the intervention. In addition, there are currently no agreed-upon standards for considering multiple resilience dividends in the planning and design of DRR interventions, as well as after their completion as part of evaluation and monitoring; such standards are needed to better inform future projects.

Here we provide an integrated framework for analyzing current challenges and shortcomings of considering different types of resilience dividends in the design, deployment, and monitoring and evaluation of DRR interventions. We use this framework to 1) explore if and what resilience dividends are considered when planning and designing DRR interventions, and 2) analyze five cases in which different multiple resilience dividends were considered, estimated, and quantified at different stages of the decision-making cycle for community DRR interventions in the context of flood risk.

### *2.3. Multiple resilience dividends in the DRR decision-making process*

The process of implementing a DRR intervention includes several steps that are more or less formalized depending on the context. The literature on DRR has identified several steps to be carried out in sequence. Brent (1998) and Mechler (2016) identified seven steps, from the identification of objectives and problems to address to monitoring and evaluation, in which short- and long-term outcomes are evaluated against the initial objectives.

For the net benefits or dividends of a DRR intervention we follow Tanner et al. (2015) and distinguish three different types (called "the triple dividend of resilience" or TDR). The first dividend accounts for losses and damages avoided in case of a disaster. The second and third dividends account for net benefits of the intervention that materialize regardless of whether a disaster occurs (i.e. the additional resilience dividends): the second dividend accounts for the economic potential of a community, household, or region that is unlocked through the intervention (e.g. by attracting more outside investments into the community through a reduced background risk); and the third dividend describes other social, environmental, and ecological co-benefits, such as ecosystem services. At each step of the decision-making process the TDR concept fulfills a different function. To better understand how multiple resilience dividends are considered at each stage of the life cycle of a DRR intervention, we combine the TDR concept with the decision-making cycle into an analytical framework. The conceptualization of the framework and its application are described in the following chapter.

## 3. Methods: Comparing multiple resilience dividends across communities in 12 countries

### *3.1. Analytical framework*

We combine the decision-making cycle by Brent (1998) and Mechler (2016) with the TDR concept, to analyze how first, second, and third dividends are considered in the different stages of a project and how they influence the outcomes of community-level DRR interventions (Fig. 1). As shown in Fig. 1, the TDR concept fulfils different functions in different stages of the life cycle. Before a decision about a particular DRR intervention has been made, it informs the decision-making process by helping stakeholders recognize and appraise the full range of benefits a specific intervention offers (Fig. 1, right). The main function of TDR at these stages is to advance existing methods and tools, such as CBA, to include the full range of net benefits and costs beyond avoided losses and to compare the benefits of different DRR interventions. After a decision has been made (Fig. 1, left), its main function is to 1) ensure that the DRR intervention is implemented in such a way that multiple resilience dividends can materialize and 2) guide the monitoring and evaluation process so that these dividends are evaluated against their predefined targets. During the evaluation process the different resilience dividends can be quantified empirically to provide crucial information both to monitor the success of the intervention and to inform future DRR projects. This facilitates an iterative learning process for how best to realize multiple resilience dividends.

We next apply the framework shown in Fig. 1 to two different data sets: an empirical data set of the different resilience dividends considered by NGOs during the planning, appraisal, and implementation stages of flood DRR interventions (Fig. 1, right) and a set of detailed flood DRR case studies covering multiple resilience dividend interventions at different stages of the project life cycle across different geographies and contexts (Fig. 1, right and left). We use the two analyses to improve understanding of how additional dividends are considered and how this influences the outcomes of DRR interventions at the community level.

### 3.2. A survey of DRR interventions implemented in eight countries

Data on community-level DRR interventions were collected through a structured online survey of three NGOs involved in community-level DRR work focusing on flood risk as part of the Zurich Flood Resilience Alliance, multi-sectoral partnership consisting of humanitarian, NGO, research, and private sector partners. Within each NGO, the respective program managers responsible for the implementation of interventions in each community were asked to provide details about the communities in which they were working, the interventions they had implemented, as well as the outcomes and current statuses of the interventions. The survey was conducted in 2019 via an online survey and covers interventions that were implemented between 2013 and 2018. The questions that were asked to collect this information can be found in Appendix A1. The questions were answered by community programme leaders after providing them with information about how the data is stored and used and asking for their informed consent. As the questionnaire did not directly involve community members or other human participants and no information on individuals was collected and/or stored no additional ethics approval was obtained.

The survey contained a mix of closed- and open-ended questions. Based on detailed descriptions of planning and implementation, interventions were coded into five groups distinguishing structural from nonstructural interventions: *Agricultural* covered interventions that involved making changes to agricultural practices to increase food security in case of a disaster or improve the livelihood of agricultural communities otherwise. *Capacity building & Education* covered interventions to improve knowledge of DRR and disaster preparedness among community members. *Forecasting & Early warning systems* covered technological interventions that provided information that allowed communities to prepare for a disaster. *Livelihood & Finance* included non-structural interventions to improve the resilience of communities to disasters using financial instruments such as insurance or saving schemes. *Water management & Hygiene* covered interventions to prevent the health and hygiene issues that often accompany disasters.

Following the framework presented in Section 2.2, we categorized the expected outcomes of each intervention reported by the NGOs according to the three types of resilience dividends. The resulting data set covered interventions implemented in communities in Bangladesh, El Salvador, Mexico, Montenegro, Nepal, Nicaragua, Peru, and the Philippines (see Fig. 2).

### 3.3. Assessing multiple resilience dividends of DRR interventions on the ground: A comparative analysis of community case studies

In addition to the empirical analysis of multiple resilience dividends during planning and implementation of individual DRR interventions, we perform a comparative analysis of five case studies to obtain insights into approaches, challenges, and obstacles in considering multiple resilience dividends in the planning, implementation, and monitoring and evaluation of DRR interventions. The five case studies were selected to address different geographies, measures, approaches, implementation stages, and supporting environments (see Fig. 2). The case studies focus on flood risk and cover all stages of the decision-making cycle in conjunction with resilience dividends. For the case study analysis, reports published by four NGOs and one governmental organization were selected based on their quality and level of detail. Each report provides detailed information about a specific case study community in a different country covering different stages in regard to implementing multiple resilience dividends DRR interventions. Case 1 (Vietnam) covers the decision-making process from identifying a problem and objectives to deciding on a specific DRR intervention. Case 2 (Indonesia), Case 4 (Afghanistan), and Case 5 (Nepal) also include the implementation stage. Case 3 (the United Kingdom) focuses on monitoring and evaluation. Based on the framework presented in Section 2.2, we prepared a set of guiding questions to structure the analysis of the case studies (see Appendix A2 for details). The data collection involved desk research and the analysis of the respective reports provided and/or published by the governmental organizations and NGOs responsible for implementing the community DRR interventions. For the case studies in Vietnam, United Kingdom and Nepal the information was additionally enhanced through interviews with key informants responsible for deploying the interventions. For that, key informants were first given a summary of the case study they were involved in and then asked to confirm and/or clarify the information that is provided in the case study to ensure the case study description is in line with their observation. The case studies are structured in three parts: a short background section describing the DRR intervention and the context in which it was implemented, a section describing which resilience dividends were considered and how, and a section describing challenges and knowledge gaps.

## 4. Findings

### 4.1. Survey of additional benefits of flood DRR interventions

A total of 40 individual DRR interventions in 91 flood-prone communities across eight countries were surveyed[1] (Fig. 2; see Appendix A3 for full list of interventions). The surveyed DRR interventions were implemented by three different NGOs with the aim to increase the communities' resilience to flooding and the survey was filled out by the eight program managers responsible for their implementation. Nearly 60% of the interventions had been implemented in Mexico or Central America (El Salvador, Nicaragua); 20% in Bangladesh; and 20% in four other countries in South America (Peru), Europe (Montenegro), or Asia (Nepal, the Philippines; Fig. 2). The most common types of interventions were *Capacity building & Education* (39%), followed by *Water management & Hygiene* (22%), *Forecasting & Early warning systems* (14.6%), *Agricultural* (12.2%), and *Livelihood & Finance* (7%). The surveyed DRR interventions were

[1] Some DRR interventions had been implemented in multiple communities; therefore, the number of individual interventions was lower than the number of communities in which projects had been implemented.

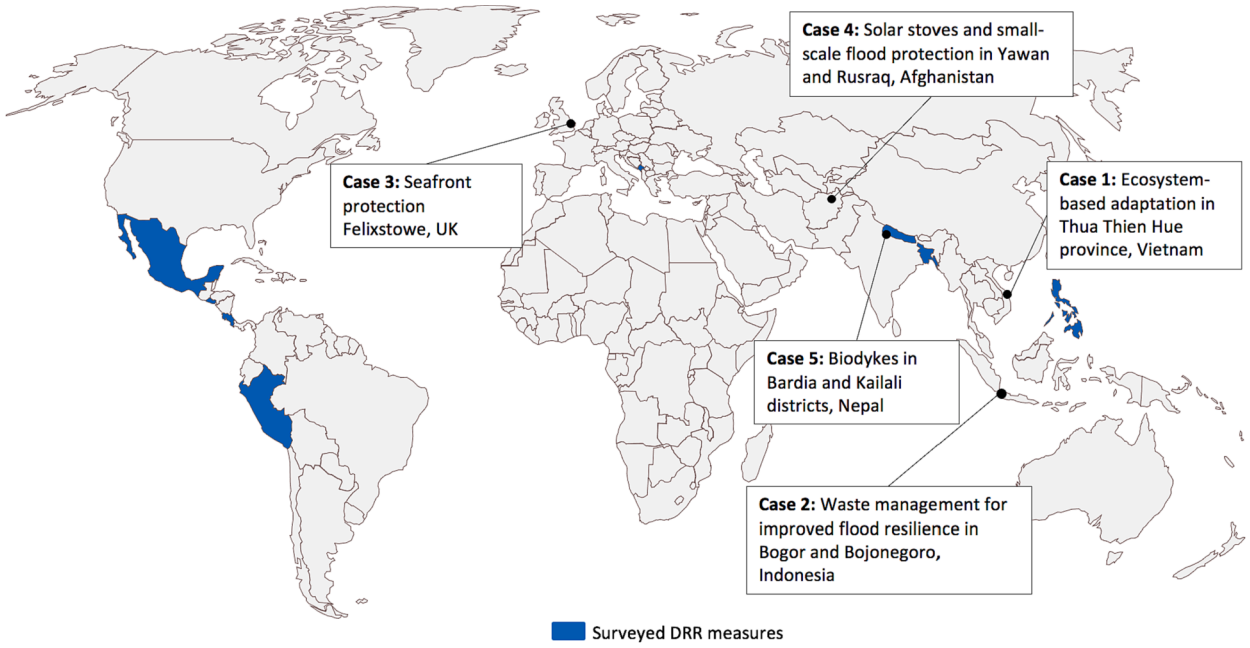


**Fig. 2.** Countries in which community DRR interventions have been implemented and surveyed (shown in blue) and the location of the case studies (black dots). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

mostly small-scale projects with setup costs between USD $85 and USD $41,700 (median: USD $905) that had been implemented in vulnerable rural communities.

Fig. 3[1] shows the resilience dividends considered (first dividend: avoiding losses and damages, second dividend: unlocking economic potential, third dividend: additional co-benefits) by type of intervention. *Capacity building & Education* (94%), *Forecasting & Early warning systems* (100%), and *Water management & Hygiene* (78%) had the most interventions expected to avoid losses and damages (first dividend). This included DRR interventions that aimed to reduce losses and damages by changing individual behavior (such as safe storage of valuables, safety training to reduce injuries in case of a disaster), which explains the high number of DRR interventions with first dividends in the *Capacity building & Education* group. Interventions in *Forecasting & Early warning systems* group had a clear focus on avoiding losses and damages, with all survey measures aiming to contribute to the first dividend, but some also considered additional development co-benefits, such as improved agricultural practices using more accurate weather data. Only 20% of the DRR interventions in the *Agricultural* group aimed to avoid losses and damages. However, all interventions in the *Agricultural* group (100%) were designed to unlock the economic potential of the communities in which they had been implemented (second dividend). Such interventions often aim to increase productivity through, for example, the planting of more profitable and adapted crops to move from subsistence to small-hold farming to create additional economic opportunities for rural communities.

The interventions expected to have additional co-benefits (third dividend) were in the *Agriculture* (80%), *Livelihood & Finance* (67%), and *Water management & Hygiene* (89%) groups. These benefits do not lead directly to economic opportunities but increase the overall welfare of communities through cleaner air and water, improved waste management, or improved food security.

No individual DRR intervention in the survey reported considered all three resilience dividends. Notably none of the interventions in the *Livelihood & Finance* group were expected to directly avoid losses and damages. However, 50% of all reported interventions in that group reported considering second and third resilience dividends. This is because the main focus of *Livelihood & Finance* interventions is to support the financial and economic stability of communities in the face of climate-related shocks.

### *4.2. Findings from the case studies*

#### *4.2.1. EbA: Thua Thien Hue province, Central Vietnam*

*4.2.1.1. Background.* As part of a DRR and research project by the Global Resilience Partnership, EbA measures have been planned and implemented in the Tam Giang Lagoon, Bu Lu river delta, and Hue City (Bubeck et al., 2019). The region suffers from flooding from the river and sea and from heavy rainfall mainly during the monsoon season. Between 1975 and 2005, 40 flood events were recorded in the region (Bubeck et al., 2012). At the same time, the province depends greatly on ecosystem services from surrounding bodies of water; for example, 100,000 people rely directly on the lagoon for fishing grounds and their water supply (Van Tuyen et al., 2010). In UNESCO-listed Hue City local ponds act as retention areas in case of heavy rainfall events but are also important for local tourism and recreation. Population growth and rapid urban expansion have led to a rapid disappearance of natural areas, putting additional pressure on available ecosystem services while increasing exposure to flooding. Moreover, as the main caregivers for both elderly

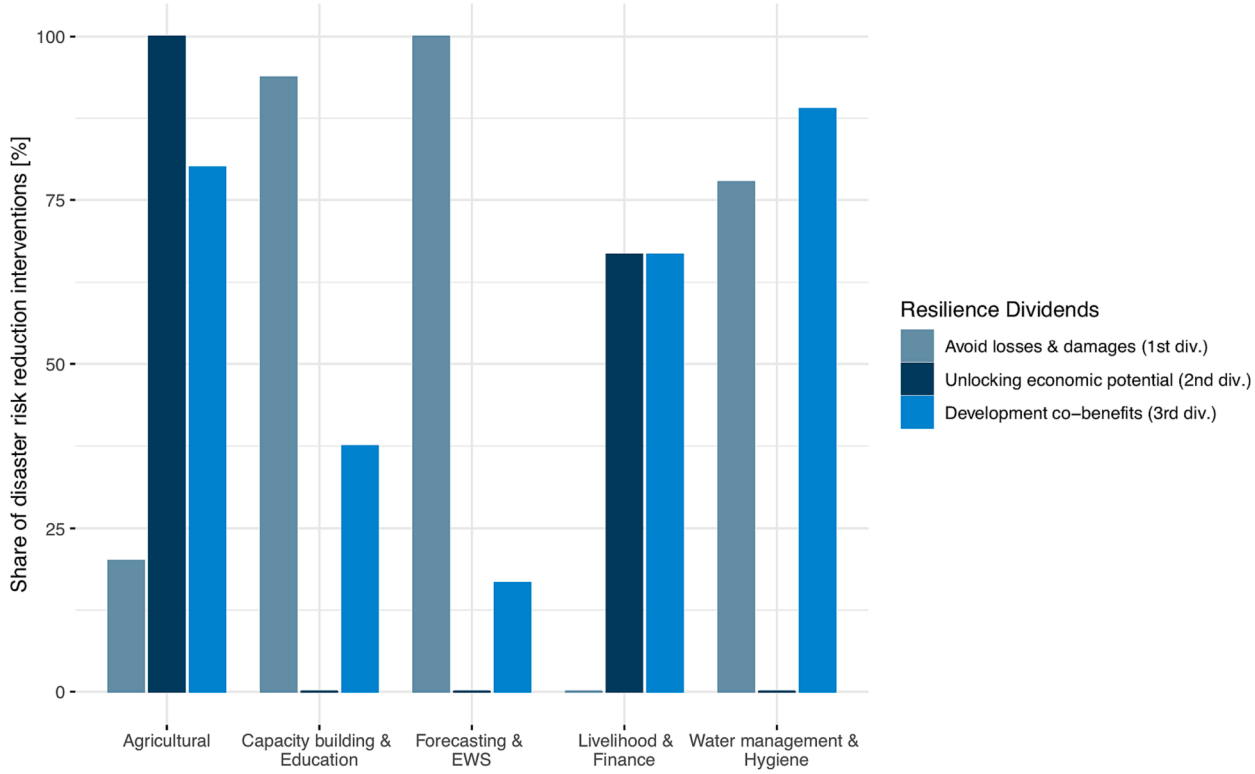


**Fig. 3.** Individual resilience dividends of five groups of disaster risk reduction (DRR) interventions: *Agricultural*, *Capacity building & Education*, *Forecasting & Early warning systems* (EWS), *Livelihood & Finance*, and *Water management & Hygiene*. The bars show the percentage of DRR interventions that considered a specific resilience dividend out of the total number of interventions in the respective group (i.e., a value of 100% for a specific dividend indicates that all DRR interventions in that group considered that resilience dividend). The total number of DRR interventions surveyed was 40.

adults and children, women have limited mobility in case of a flood disaster and have fewer opportunities than men to build up savings for a fast financial recovery.

*4.2.1.2. Consideration of resilience dividends.* Focusing on the most vulnerable groups in the community, who depend directly on fisheries as a food source as well as a source of additional income from tourism, project organizers identified EbA as a suitable DRR intervention in the planning and appraisal stage, as it both supports ecosystem services and protects against flooding. Three measures were implemented. First, mangroves were planted at the Tam Giang Lagoon and Bu Lu river to reduce wave energy and coastal erosion while providing habitats for fisheries. Second, urban bodies of water in Hue City were restored to reduce the risk of surface water flooding through improved drainage while improving the recreational value of the ponds, which is important for local tourism. Third, communication campaigns were launched to raise awareness of flood resilience and EbA among the local population. Additional resilience dividends were intentionally considered in the planning process, including a second dividend through an anticipated increase in tourism and improved livelihoods from fisheries. During the implementation process, additional unintentional resilience dividends were recorded, including increased participation in planning and decision making around DRR and CCA among local women through an active engagement in awareness campaigns by the local women's union, which emerged as a co-benefit during the implementation phase. As part of the planning process, several approaches were used to quantify or define additional dividends: quantitative surveys of flood-prone households as well as domestic and international tourists, analysis of self-assessed well-being to examine the impacts of floods and ecosystem services on individual welfare, and willingness to pay analysis of different resilience dividends (reduced damage, increase in seafood production, increased tourism). A CBA was used to quantify the benefits of the different dividends. In all cases additional dividends contributed to positive CBA ratios (benefit-to-cost ratios: 2.3 for mangrove reforestation, 34 for pond restoration), and in the case of pond restoration second and third dividends were already resulting in positive CBA ratios.

*4.2.1.3. Challenges and knowledge gaps.* A lack of previous experience with EbA and concerns about the effectiveness of avoiding losses and damages made local decision makers reluctant to implement the proposed EbA interventions. Perceptions of additional resilience dividends, such as a boost in the tourism industry and their usefulness for the community, were often biased by the personal values of local decision makers and concerns about how long-term conservation should be balanced with immediate economic needs. Although

stakeholders acknowledged that EbA could deliver wider benefits and might therefore be a better long-term strategy compared to hard resilience measures such as flood walls, they remained concerned that the long amount of time between the implementation of a newly restored ecosystem and when it would start delivering benefits (including protection from losses and damages) might not address their immediate need to effectively reduce their disaster risk. A survey of local decision makers also revealed a mismatch between existing national government strategies for connecting EbA with CCA and DRR and knowledge of the local decision makers in this regard (Wolf et al., 2020). Successful pilot projects already implemented elsewhere were reported to help communicate the wider benefits and efficacy of EbA to local decision makers.

#### 4.2.2. *Waste management for improved flood resilience: Bogor and Bojonegoro, Indonesia*

*4.2.2.1. Background.* Bogor and Bojonegoro (population 161,000) are rural/semi-urban villages south of Jakarta. Their local economies revolve around tourism from the nearby capital. The communities are frequently affected by flooding (four times alone in 2015) from the Ciliwung river. Other hazards include landslides, biohazards, air pollution, and contamination associated with local handling of garbage and waste. A flood resilience assessment conducted by the International Federation of Red Cross and Red Crescent Societies (IFRC) as part of the Flood Resilience Program identified garbage disposal as a main contributor to increased flooding, as 70% of households dump their garbage into the river (IFRC, 2017, Laurien and Keating, 2019). This results in blockages and subsequent flooding that also affect communities downstream.

*4.2.2.2. Consideration of resilience dividends.* The introduction of a local waste management system was found to be the most suitable approach to reducing the flood risk and subsequent damage in the communities (first dividend). As part of the planning process, second and third dividends were considered: Using recycled materials to create handicrafts was proposed as a way of creating new opportunities for livelihood (second dividend), and it was suggested that compost be used as organic fertilizer (third dividend). The upfront investment in and cost of running the recycling facility will be fully covered by the revenue generated from selling recycled plastics. A local waste management company was contracted to set up and operate the recycling facility. Local decision makers were involved in the planning process and provided a suitable site for the waste management facility. Local civil organizations, such as the local women's association, were actively involved in establishing a community-level garbage management group. The project was implemented as part of Indonesia's decentralized DRR strategy, and therefore responsible organizations at the national level were not involved. Only qualitative risk assessments have been conducted, although a separate CBA was performed to estimate whether waste recycling could cover the cost of the recycling facility.

*4.2.2.3. Challenges and knowledge gaps.* Although no specific challenges were reported in the planning and implementation phase, the materialization of all three dividends depends to a large degree on changes in waste management behavior among both the local population and visitors. Additional dividends can be realized almost immediately after implementation, as the supply chain for recycled waste and revenue streams was set up in the planning stage as a condition for building the recycling facility. Although the revenue generated by the recycling plant is sufficient to cover purchase costs and operation of the plant, garbage collection is primarily organized by volunteers whose compensation is not sufficient to cover their cost of living. In addition, volunteers have reported reputational issues related to volunteering as garbage collectors (PMI, 2018).

#### 4.2.3. *Seafront protection: Felixstowe, United Kingdom*

*4.2.3.1. Background.* The town of Felixstowe, an urban area on the eastern coast of England with a population of 24,000, has the largest container harbor in the United Kingdom. Felixstowe is affected by flooding from the sea and coastal erosion, which is expected to increase as a result of rising sea levels and increased storms. To protect property, commercial enterprises and amenity beaches, recreational gardens, and key infrastructure along the seafront, in 2012 project organizers requested funding from the Environment Agency, the national body responsible for flood risk management. The aim of the project was to manage the flood risk along the seafront for the next 100 years. Risk assessments estimated that 1,491 properties and critical infrastructure would be affected by coastal erosion, with a projected total loss of GBP 148.3 million, in a do-nothing scenario. A CBA for the preferred option of constructing 18 straight rock groynes over a length of 1.3 km yielded a benefit-to-cost ratio of 11.3.

*4.2.3.2. Consideration of resilience dividends.* Although no additional dividends were formally considered in the planning and implementation stage, multiple resilience dividends were recorded as part of the monitoring and evaluation of the intervention 8 years after its completion (Eyres et al., 2020). As a second dividend, the increased protection from the new flood defenses stimulated new investment in the property sector, including the construction of a new hotel that created 25 new jobs and the restoration of two existing hotels that had previously been in decline. With additional investment in the housing sector and amenities, the seafront was fully restored, with positive effects on retail and business. A significant increase in visitors was recorded between 2012 and 2015, around 50% of which could be attributed to the new flood protection scheme. Based on this new evidence the initial CBA was updated to reflect an almost 3 times larger benefit-to-cost ratio of 31.3. Another second resilience dividend attributable to the DRR intervention was an increase in annual local authority revenue of GBP 283,680 from parking and seafront visitor accommodation. Third dividends in the form of increased recreational value and attractiveness of the restored seafront were only partly quantified in terms of an increase in visitors and an overall increase in attractiveness as a tourist destination among younger demographics. An assessment and

retrospective evaluation of additional resilience dividends by the Coastal Partnership East, a group of local authorities, was done as part of the monitoring and evaluation stage to support the business case for similar projects and future interventions. The Coastal Partnership East developed a matrix system of both quantitative measurements and qualitative assessments of additional resilience dividends that materialized 3 years after the completion of the DRR intervention.

*4.2.3.3. Challenges and knowledge gaps.* The main challenge was the lack of both appraisal and monitoring/evaluation frameworks for including additional resilience dividends in the planning process and defining what could and needed to be quantified during monitoring and evaluation. It was also unclear what additional dividends funders would accept or consider when making future decisions about funding applications. Applying for explicit multiple resilience dividend projects is also complicated by the need for additional co-funding in case additional resilience dividends and co-benefits are explicitly included in a proposal but do not specifically aim to reduce losses and damages (EA, 2018).

### *4.2.4. Solar stoves and small-scale flood protection: Yawan and Rusraq, Afghanistan*

*4.2.4.1. Background.* The Yawan district of eastern Afghanistan is a mountainous region with a population of around 13,000. The majority of the population in the Yawan district are poor farmers practicing unsustainable cultivation of marginal land prone to extreme weather. A total of 70% of people depend on agriculture for their livelihood, and almost 70% live below the national poverty line. Flash floods and mudslides frequently block roads, making communities inaccessible to vehicles. All communities in this case study have been impacted by an extreme flood event in the past 10 years. The NGO Concern Worldwide together with members of the local community conducted a flood resilience assessment and a participatory CBA to identify potential DRR interventions. Given the underinvestment in critical infrastructure, such as roads, three interventions were identified: 1) small-scale flood defenses using existing community knowledge, sourced from local materials and managed by community disaster committees; 2) a mainstreaming of flood risk management into community development planning to ensure that flood risk is included by Community Development Councils; and 3) the use of solar stove technologies for food and water security, and environmental sustainability (Laurien & Keating 2019). The implementation of these measures was supported by several government entities, including the National Disaster Management Authority and the Directorate of Rural Rehabilitation and Development, which monitor flood protection structures.

*4.2.4.2. Consideration of resilience dividends.* Although flood risk was a key concern, the resilience dividends considered in the planning process focused equally on the development needs of the community. For example, for the introduction of solar stoves, the first dividend only plays a role as a second-order effect if the second (safer and more efficient cooking that allows for more economic possibilities) and third (improved food and water security, more sustainable use of local resources) dividends materialize. The communities in this region are very vulnerable to disaster-induced (transitory) food and water insecurity when energy for cooking and boiling water becomes unavailable; at the same time, collecting firewood for use in wood-burning stoves removes local vegetation (and its ability to store water and reduce surface runoff) and thus increases flood risk.

*4.2.4.3. Challenges and knowledge gaps.* Because the materialization of the first dividend depends directly on successful materialization of second and third dividends, the DRR component of the intervention will materialize long after development and the CCA component. Long-term monitoring and evaluation is necessary to evaluate the success of the project. This information is generally difficult to obtain given the short timelines of development projects.

### *4.2.5. Biodykes: Bardia and Kailali districts, Nepal*

*4.2.5.1. Background.* The Bardia and Kailali districts are located in northwestern Nepal on the Indian border. The two communities assessed consist of around 200 households. In both cases the main livelihood of the community members is agriculture, which is also key to food security. The majority of the agricultural land is highly susceptible to regular flooding from tributaries of the Karnali river during the monsoon season, which destroys crops, puts livestock at risk, and leaves sand deposits. Both communities have a low standard of living. As part of the Nepal Flood Resilience project the NGO Practical Action has supported the construction of biodykes to reduce bank erosion and loss of agricultural land during flooding as well as to save lives and property. In the face of frequent and intense climate-induced disasters, biodykes have emerged as a DRR intervention that can be integrated well into local plans and community-led programs across Nepal. Biodykes are a bioengineering solution that can control bank erosion and control flood risk by mediating water flow through a combination of vegetation and structural measures. Vegetation controls the erosion of embankments built from locally available material such as sand, rocks, and soil. Initially sandbags are used to control erosion, but biological measures gradually become more effective when plants mature and their roots start to stabilize the soil. Local grass, shrub, and tree species are used as vegetation. The building of biodykes with lengths of 220 and 1,500 m in two communities was coordinated by the Local Disaster Management Committee.

*4.2.5.2. Consideration of resilience dividends.* The main motivation for introducing biodykes instead of hard infrastructure measures such as concrete flood walls was the lower construction and maintenance costs. The difference in cost was quantified through a cost comparison, which found that biodykes were around half as expensive as an equivalent measure made from concrete walls, mainly because of lower maintenance costs as the biodykes can be maintained by members of the community. In addition, second and third

dividends were considered qualitatively as part of the planning process. Second dividends were an expected increase in agricultural yield (through both avoided losses and damages to existing crops and livestock as well as the creation of new forest products from biodyke materials such as fodder and fuel wood) and lower outmigration as a result of increased opportunities in the community. Third dividends of the biodykes included $CO_2$ sequestration and the creation of new wildlife habitats.

*4.2.5.3. Challenges and knowledge gaps.* Despite their higher costs and lower potential for multiple resilience dividends, local decision makers as well as members of the community favored concrete flood walls and comparable hard resilience measures, which are also being implemented in the region. The main reason for supporting these over the biodykes was concerns about the slow materialization of the resilience dividends. In regard to avoiding losses and damages (the first resilience dividend), the vegetation on biodykes needs to mature before it can deliver full protection from flooding, whereas concrete walls offer protection right after their implementation. The focus on the first dividend, and as a consequence the preference for hard resilience interventions among the local community, revealed a mismatch between national strategies and local demands. Whereas national policies actively encourage the use of nature-based solutions as cost-efficient way to align DRR with CCA activities to provide a large number of additional benefits, the local community remained in favor of concrete walls even after the implementation of the biodykes. Since their implementation in 2015, the biodykes have been reported to efficiently prevent river bank erosion and flooding, including the depositing of sand on agricultural land, in one of the communities. So far, the intended additional resilience dividends, especially an increase in fodder for livestock, have materialized, and local communities have also reported new knowledge and skills as a valuable additional benefit that was not initially considered in the planning stage. However, a number of unintended disadvantages and co-costs, such as wild animals hiding in the biodykes and destroying crops and conflict over plant resources grown on the biodykes, have been reported as well, reducing the overall attractiveness of the additional resilience dividends.

**Table 1**
Summary of case studies.

| | |
|---|---|
| **Case 1: Ecosystem-based adaptation: Thua Thien Hue province, Central Vietnam** | |
| **Intervention:** | Planting of mangroves to reduce wave energy and coastal erosion and restoration of urban bodies of water to reduce the risk of surface water flooding |
| **Decision-making stage (s)** | Identify problems and objectives, Assess risk, Appraise options, Make decision |
| **Approach:** | Quantitative surveys (impact of floods and ecosystem services on well-being), willingness to pay analysis, cost-benefit analysis (CBA) for individual dividends |
| **Challenges:** | Skepticism among local decision makers toward the efficacy of ecosystem-based adaptation for risk reduction, perceptions of the usefulness of additional benefits were biased by the personal values of local decision makers |
| **Case 2: Waste management for improved flood resilience: Bogor and Bojonegoro, Indonesia** | |
| **Intervention:** | Introduction of a community waste management system, including the establishment of a recycling facility to prevent flooding caused by disposing of garbage in the river |
| **Decision-making stage (s)** | Identify problems and objectives, Assess risk, Appraise options, Make decision |
| **Approach:** | Assessment of community flood resilience, CBA to estimate whether additional revenue from recycling can cover the cost of the recycling facility |
| **Challenges:** | No specific challenges were reported, but the success of the intervention depends greatly on changes in waste management behavior among the local population |
| **Case 3: Seafront protection: Felixstowe, United Kingdom** | |
| **Intervention:** | Construction of rock groynes to protect the urban seafront from coastal erosion and increased flood risk from rising sea levels for the next 100 years |
| **Decision-making stage (s)** | Monitor and evaluate |
| **Approach:** | Formal CBA of risk reduction versus a do-nothing scenario, ex-post attribution of increased job opportunities and additional local authority revenue from the intervention |
| **Challenges:** | Lack of formal appraisal and monitoring/evaluation (M&E) approaches for additional resilience dividends, it was unclear which resilience dividends could and should be quantified, application for multiple resilience dividend projects was complicated by co-funding requirements |
| **Case 4: Solar stoves and small-scale flood protection: Yawan and Rusraq, Afghanistan** | |
| **Intervention:** | Small-scale flood protection using local knowledge and materials, mainstreaming of flood risk management into community development planning, the use of solar stove technologies to ensure food and water security and to reduce the chopping of wood |
| **Decision-making stage (s)** | Identify problems and objectives, Assess risk, Appraise options, Make decision |
| **Approach:** | Assessment of flood resilience to identify resilience strengths and weaknesses in the communities, participatory CBA |
| **Challenges:** | Long time frames for the materialization of additional resilience dividends (e.g., the effects of solar stoves on reductions in flood risk), long-term M&E processes were needed |
| **Case 5: Biodykes: Bardia and Kailali districts, Nepal** | |
| **Intervention:** | Construction of biodykes (banks built from local materials and stabilized by vegetation) to reduce bank erosion and flooding of agricultural areas |
| **Decision-making stage (s)** | Identify problems and objectives, Assess risk, Appraise options, Make decision |
| **Approach:** | Semi-quantitative cost-benefit comparison of biodykes and conventional flood walls |
| **Challenges:** | Lack of support for biodykes among local decision makers because of long time frames for risk reduction, conflict over uneven distribution of resilience dividends among community members |

Table 1 provides summaries of the five case studies, including short descriptions of the DRR intervention and its context, the steps in the decision-making process, methods and approaches used, as well as potential challenges.

Table 2 provides a detailed summary of each dividend considered in the individual case studies grouped by type of resilience dividend as described in Section 2.3.

## 5. Discussion and limitations

This analysis of multiple resilience dividends along each step of the decision-making cycle reveals general as well as context-specific challenges and knowledge gaps among the community DRR interventions investigated. In the developing countries analyzed, high-level policies (mostly on the national level) that align DRR, CCA, and development are already in place and (at least in theory) provide the environment necessary to consider multiple resilience dividends in community DRR interventions (see the case studies for Vietnam, Nepal, and Afghanistan). This development is driven by both budget constraints and the often immediate development needs of the vulnerable communities, as considering multiple resilience dividends is seen as a cost-effective strategy for reducing disaster risk while stimulating community development.

The UK case study shows that in the developed world institutional silos are more prevalent and DRR is traditionally seen as a singular task with the goal of avoiding losses and damages. Attempts to break through these silos to deliberately include multiple resilience dividends in the planning and appraisal of interventions are complicated by separate funding sources and funding bodies for DRR, CCA, and community development (see the UK case study), despite the recent emphasis on investments in DRR for resilience as highlighted in the Sendai Framework. This is further complicated by top-down, techno-scientific approaches and funding schemes for DRR, which often increase incentives for hard infrastructure solutions with little focus on community-specific additional social and environmental dimensions of disaster resilience making it harder to realize resilience dividends for example from ecosystem services (Imperiale & Vanclay, 2020). The observation that developing countries are taking a leading role in acknowledging the multiple resilience dividends of DRR in national policy is in line with findings by Fung and Helgeson (2017).

However, the more integrated policies in the developing world are often counteracted by a high level of skepticism and concern among local decision makers and communities over how best to apply the multiple resilience dividend approach at the community level. Such challenges were also reported by Keating and Hanger-Kopp (2020), who investigated the application of disaster resilience by international development practitioners. Dedicated multiple resilience dividend interventions, such as EbA (Vietnam) and nature-based solutions (Nepal), are often framed as new and innovative solutions that can yield greater additional resilience dividends than more conventional approaches (such as flood walls). However, they often have more design uncertainty when and if dividends materialize, as their success depends on more additional factors (Onuma & Tsuge, 2018). In all cases analyzed in this study, the DRR

**Table 2**
Summary of resilience dividends considered in the five case studies.

| | First dividends: Avoiding losses and damages | Second dividends: Unlocking economic potential | Third dividends: Additional co-benefits |
|---|---|---|---|
| **Ecosystem-based adaptation: Vietnam** | • Reduced damages to fishing boats from coastal flooding<br>• Reduced coastal erosion<br>• Reduced damage to residential homes and businesses in urban areas | • New habitats for fisheries for improved livelihoods and tourism<br>• Increased support for small local businesses through increased recreational value | • Increased participation of women in local disaster risk reduction and climate change adaptation decisions |
| **Waste management: Indonesia** | • Prevention of frequent flood damage in the community<br>• Reduced flood damage in downstream communities | • Improved livelihoods through the creation of handicrafts from recycled material | • Use of compost as organic fertilizer |
| **Seafront protection: United Kingdom** | • Reduced flood damage to residential property, commercial enterprises, recreational areas, and key infrastructure | • Creation of new jobs through the restoration of hotels and other services<br>• Increased number of visitors<br>• Increased annual revenue for local authority from taxes and fees | • Increased recreational value through seafront restoration<br>• Increased attractiveness as a tourist destination |
| **Solar stoves and small-scale flood protection: Afghanistan** | • Direct reduction in flood risk through small-scale flood protection and improved flood risk management<br>• Indirect reduction in flood risk through improved water retention | • Improved economic possibilities for women and girls through safer and more efficient cooking | • Improved food and water security<br>• More sustainable use of local resources (firewood, drinking water) |
| **Biodykes: Nepal** | • Reduced flood damage to agricultural land | • Increased agricultural yields (including new crops grown on the biodykes)<br>• Less outmigration | • $CO_2$ sequestration through vegetation grown on the biodykes<br>• New wildlife habitats |

interventions were implemented on the back of a recent disaster, which increased pressure on local decision makers to act quickly to reduce the risk for future losses and damages, further amplifying concerns that efficacy in reducing losses and damages is sacrificed for more second and third dividends in these new and innovative interventions (Bubeck et al., 2019).

Despite their initial concerns and opposition, local decision makers in Nepal and Vietnam acknowledged the trade-offs between the speed with which the implemented DRR intervention would be able to reduce losses and damages, its effectiveness, and the long-term benefits of additional resilience dividends from the intervention for their communities. Local decision makers in these two communities concluded that the interventions would likely be beneficial for their communities in the long run. However, interventions whose sole purpose is to reduce losses and damages (such as concrete flood walls) and that have potentially fewer additional resilience dividends offer more immediate and efficient protection and were the preferred option when risk reduction is urgently required.

Concerns around the ability of multiple resilience dividend interventions to effectively reduce risk are closely linked to the perceived usefulness of the additional resilience dividends among both local decision makers and communities. The case study on biodykes in Nepal shows that despite the successful materialization of resilience dividends such as additional forest products and $CO_2$ sequestration, the emergence of unexpected co-costs such as conflicts around the distribution of the new resources and the fact that newly settled wild animals were destroying crops in the nearby fields reduced overall acceptance of the intervention. One way to increase buy-in from local decision makers for interventions with multiple resilience dividends is to focus on those resilience dividends in the decision-making process that are considered beneficial by the community (including their co-costs). However, skepticism toward DRR interventions with multiple resilience dividends, such as EbA, is also fueled by personal values and knowledge gaps among decision makers who prefer a more traditional approach to DRR, as a survey by Wolf et al. (2020) in Vietnam revealed. One approach to successfully overcoming high levels of skepticism and closing knowledge gaps is to implement pilot projects elsewhere that generate convincing evidence of the materialization of the resilience dividends of a proposed intervention in other communities.

However, evidence from pilot projects is still rare, partly because the field lacks approaches and frameworks that allow the inclusion, tracking, and recording of multiple resilience dividends throughout the entire life cycle of an intervention (see Fig. 1). To make progress in realizing multiple resilience dividends of community DRR interventions and to align these dividends with targets set in high-level policies, further work is necessary. Integrated decision-making frameworks for multiple resilience dividends need to be established that consistently cover the entire decision-making cycle. This is necessary to both consider multiple resilience dividends early on in the planning and appraisal process and follow each dividend throughout implementation and materialization. While our study is able to demonstrate how multiple resilience dividends are considered by analyzing individual data sets and case studies which cover either one or multiple steps of the decision-making cycle, there is no case study that covers each step for a single DRR intervention. Having such information would be important to understand during which steps considering multiple resilience dividends is particularly difficult and how these challenges could be overcome.

The results of the quantitative analysis of the community DRR interventions in Section 4.1 show that there is no silver bullet for resolving all issues identified by a community at once. Most notable is that some measures do not directly contribute to avoiding losses and damages, although they contribute to a lower disaster risk in the community (e.g., through the increased financial resilience of households). Despite the detailed survey of DRR interventions, it was not possible to validate the reported information especially how likely the reported resilience dividends will materialize. In cases where materialized resilience dividends were reported, the authors could not fully control for over- or understating some of the successful outcomes due to the research design relying on self-reports by the implementing NGOs. This also includes the beneficiaries (i.e. members of the respective communities) which could not be directly asked in the chosen research design and could therefore not provide any additional information on the success of specific DRR interventions. However, strict monitoring and evaluation processes within each NGO were in place to prevent misreporting. A comparison between different NGOs also did not reveal any organization-specific bias towards more positive or negative outcomes.

Instead of maximizing resilience dividends based on a specific metric (e.g., monetary benefits), future decision-making approaches need to identify and generate those dividends that are most needed and demanded by the community. Combining the structured approach of multiple resilience dividends (e.g., through the TDR approach presented in this paper) with participatory decision making can help create solutions tailored to needs identified by the community. This would entail a shift from the current use of CBA, in which one main goal is identified for an intervention (e.g., avoiding losses and damages to residential homes) and additional co-benefits are considered primarily to increase attractiveness to funders by inflating benefit-to-cost ratios regardless of whether the co-benefits actually meet the needs of the community. Such an integrated and participatory approach offers an opportunity for knowledge sharing and co-production between approaches in the developing world, where the integration of DRR and sustainable development for communities is more established, and recent methodological advancements in tools for appraising multiple resilience dividends in the developed world (Michel-Kerjan et al., 2013, Craig et al., 2017, Fung et al., 2020).

## 6. Conclusion

Disasters from climate-related hazards have caused significant losses and damage globally over the past decades and are expected to increase without additional action because of an increase in exposed assets, changing weather patterns, and rising sea levels. Although more investment in pre-event disaster resilience is demanded by global key agreements to reduce disaster risk worldwide, most money invested still goes to post-event emergency response and recovery. The concept of multiple resilience dividends aims to increase the attractiveness of investment in pre-event disaster resilience by highlighting the additional economic, social, and ecological co-benefits that materialize after a disaster. Although the concept is now frequently used in high-level discussions to strengthen the narrative for investment in resilience, it remains unclear how it can be translated into tangible, local actions that reduce disaster risk, stimulate socioeconomic development, and create ecological benefits. Here we used a newly developed integrated framework to

analyze challenges and knowledge gaps that have so far prevented this high-level concept from being widely applied to DRR intervention planning and implementation on a community scale.

Using a mixed-methods approach marked by empirical data on community-level DRR interventions and in-depth case study analysis, we identified two mutually influencing key challenges as potential barriers to applying this concept at the community level. During the planning stages, a lack of evidence for and agreement on how to consider and appraise additional resilience dividends makes it difficult for practitioners and local decision makers to design DRR interventions that create resilience dividends that support the community's economic, social, and ecological development. It is also challenging to assign monetary values to benefits that are difficult to quantify. A lack of monitoring and evaluation routines that are able to track and quantify materialized resilience dividends leads to both intended and unintended resilience dividends going unnoticed after the implementation of a DRR intervention, ultimately failing to contribute to the still scarce evidence base on quantified multiple resilience dividends. A lack of agreement on what to monitor and evaluate can also create significant search costs, which in the case of peripheral resilience dividends can be higher than the actual benefits (Dicker et al., 2021).

Both structured consideration of multiple resilience dividends during planning and appraisal as well as quantification after their successful materialization are necessary to overcome the skepticism of local decision makers toward this approach. Skepticism is often fueled by concerns that the ability of a DRR intervention to reduce risk is sacrificed for a wider range of additional resilience dividends that might not even be demanded by the community. Rethinking is required when applying the multiple resilience dividend approach to community-level decision making. One of the keys to the success of the concept in high-level discussions has been a shift away from seeing investment in resilience solely as means to reduce risk with unsuccessful outcomes if no disaster happens. The same narrative can become a source of concern among local decision makers who need to demonstrate that reducing the community's disaster risk is their key priority, especially when an intervention is implemented on the back of a recent disaster.

We therefore propose an integrated decision-making framework that allows the systematic inclusion, appraisal, implementation, and evaluation of individual resilience dividends at each stage of the decision-making process while reducing search costs for benefits. This facilitates a transparent and tailored approach in which those resilience dividends (including avoiding losses and damages) are included (and quantified) in the planning process that are required by communities to support local buy-in. Accounting for those longer-term community needs also supports a learning process in the respective communities which can lead to a more transformative change in their disaster resilience and development. At the same time, it allows the systematic recording and evaluation of resilience dividends once they materialize to contribute to the iterative improvement of the evidence base on multiple resilience dividends of community DRR interventions across the globe.

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**Declaration of Competing Interest**

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

**Data availability**

Data will be made available on request.

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**Appendix**

*Appendix A1. : Flood disaster risk reduction intervention questionnaire*

1. Name of flood risk intervention
2. Organisation
3. Country
4. Is this intervention new, replicated, or adapted?
5. Where did you find the information to help design your intervention? (E.g. your organisational database; a colleague; the Flood Resilience Portal; discussions with peers). Please be as specific as possible - so, if online, where exactly?

6. Describe (briefly) the intervention - how does it work?
7. Which - if any - vulnerable group(s) do you hope the intervention will benefit?
8. If relevant, how did this intervention benefit the vulnerable group(s) listed above?
9. What was the scale of the impact?
10. What is the approximate actual cost to set up this intervention? (USD)
11. What is the approximate actual annual maintenance cost? (USD)
12. What non-financial costs were required (including voluntary time)?
13. Which source(s) of resilience are you targeting?
14. Did a flood take place after the intervention was implemented?
15. Did the intervention contribute to improved community flood resilience? Please provide any evidence that the intervention was effective.
16. Is there evidence of the flood event being different to previous floods due to this intervention? If so, how?
17. Did the community or other stakeholders have any feedback about the intervention?
18. Did the intervention provide the benefits/outcomes/results you expected?
19. Any unexpected co-benefits?
20. Any unexpected harm or problems? Please describe (with evidence) how these affected the community.
21. How will the intervention be sustained beyond the project period?
22. Has the intervention been replicated or scaled up locally, regionally or nationally or are there any plans for this? Please describe.
23. Who should be the contact for anyone requiring further information about this intervention? (Name, role, email)

## Appendix A2. : Case studies: Guiding questions

1. In what context has the resilience project been implemented (country/region, developing vs. developed country, urban vs. rural location, number of beneficiaries, number of affected people living in the area)?
2. What are the main hazards the community or area is facing (flooding, landslide, drought, etc.)?
3. What are the preconditions (skills, capacities, framing, project context, theory of change, etc.)?
4. What role do institutions play (implementing standards set by national and local governments, setting reporting and evaluation criteria, etc.)?
5. What types of measures (hard resilience, nature based, soft resilience, capacity building, education programs, etc.) are being implemented or considered?
6. What phase is the project currently in (planning, implementation, completed)?
7. What tools and methods are being used?
8. What evidence of additional dividends (second and third dividends) is reported or was initially considered?
9. What are the challenges in different stages of the decision-making process (tools, business case not convincing to decision makers, institutional barriers, etc.)?
10. What factors are particular to this case (i.e., what aspects of this case are unique or can be pinned down to a specific circumstance)?
11. Is there a focus on multiple or compound risks (e.g., beyond flooding)?

## Appendix A3. : Flood DRR interventions

See CSV file attached.

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