Grantham Research Institute on Climate Change and the Environment

Centre for Climate Change Economics and Policy

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

Viktor Rözer, Swenja Surminski, Finn Laurien, Colin McQuistan, Reinhard Mechler

April 2021

Centre for Climate Change Economics and Policy Working Paper No. 385
ISSN 2515-5709 (Online)

Grantham Research Institute on Climate Change and the Environment Working Paper No. 357
ISSN 2515-5717 (Online)

E·S·R·C ECONOMIC & SOCIAL RESEARCH COUNCIL

The Grantham Foundation for the Protection of the Environment

University of Leeds

LSE The London School of Economics and Political Science

The Centre for Climate Change Economics and Policy (CCCEP) was established by the University of Leeds and the London School of Economics and Political Science in 2008 to advance public and private action on climate change through innovative, rigorous research. The Centre is funded by the UK Economic and Social Research Council. Its third phase started in October 2018 with seven projects:

1. Low-carbon, climate-resilient cities
2. Sustainable infrastructure finance
3. Low-carbon industrial strategies in challenging contexts
4. Integrating climate and development policies for 'climate compatible development'
5. Competitiveness in the low-carbon economy
6. Incentives for behaviour change
7. Climate information for adaptation

More information about CCCEP is available at www.cccep.ac.uk

The Grantham Research Institute on Climate Change and the Environment was established by the London School of Economics and Political Science in 2008 to bring together international expertise on economics, finance, geography, the environment, international development and political economy to create a world-leading centre for policy-relevant research and training. The Institute is funded by the Grantham Foundation for the Protection of the Environment and a number of other sources. It has 11 broad research areas:

1. Climate change adaptation and resilience
2. Climate change governance, legislation and litigation
3. Environmental behaviour
4. Environmental economic theory
5. Environmental policy evaluation
6. International climate politics
7. Science and impacts of climate change
8. Sustainable finance
9. Sustainable natural resources
10. Transition to zero emissions growth
11. UK national and local climate policies

More information about the Grantham Research Institute is available at www.lse.ac.uk/GranthamInstitute

Suggested citation:
Rözer V, Surminski S, Laurien F, McQuistan C, Mechler R (2021) *Multiple resilience dividends at the community level: A comparative study on disaster risk reduction interventions in different countries*. Centre for Climate Change Economics and Policy Working Paper 385/Grantham Research Institute on Climate Change and the Environment Working Paper 357. London: London School of Economics and Political Science

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

Viktor Rözer[1], Swenja Surminski[1], Finn Laurien[2], Colin McQuistan[3], Reinhard Mechler[2]

[1] Grantham Research Institute, London School of Economics and Political Science, London, UK

[2] International Institute for Applied System Analysis, Systemic Risk & Resilience Group, Laxenburg, Austria

[3] Practical Action, Climate Change and Disaster Risk Reduction, Rugby, UK

Correspondence to: Viktor Rözer (v.roezer@lse.ac.uk)

Abstract

The costs of disasters have been increasing in many parts of the world as a result of an increase in exposed and vulnerable assets as well as the effects of climate change. However, investments in disaster risk reduction (DRR) remain insufficient to manage these growing risks. To make investments in DRR more attractive and to shift investments from post-event response and recovery to pre-event resilience, there has been a push to account for the full range of benefits of those investments including economic, ecological and social 'resilience dividends'. While the concept of 'multiple resilience dividends' is now frequently used to strengthen the DRR narrative, it has not yet been widely applied in practice when appraising DRR interventions. The paper analyses the knowledge gaps and challenges that arise from applying the 'multiple resilience dividends' in planning, implementation and evaluation of disaster risk reduction interventions on the community level. A newly developed framework is used to analyse empirical survey data on community level DRR interventions as well as five in-depth community case studies in Vietnam, Nepal, Indonesia, Afghanistan and the UK. The analysis reveals a disconnect between the available planning tools and the evidence on materialized multiple resilience dividends, which pose a key obstacle in successfully applying the concept on the community level. The paper concludes that a structured consideration of multiple dividends of resilience from the planning to the monitoring stage is important to secure local buy-in and to ensure that the full range of benefits can materialize.

1. Introduction

Disasters from climate related hazards have caused USD 2.2 trillion of losses and damages since 2000 and have affected approximately 3.9 billion people globally (EM-DAT, 2020). In many regions, especially in the developing world, disasters have considerable long-term implications such as severe disruptions of economic development and livelihoods (Shabnam, 2014; Davis & Alexander, 2015), worsening levels of poverty (Hallegatte and Rozenberg, 2017) and increasing government debt (Koetsier, 2017). Socio-economic trends and climate change are expected to raise the risk levels even further across many parts of the world, leading to more losses and damages in the future without further action (Bouwer 2019, Formetta & Feyen 2019, IPCC 2018). In order to avoid and reduce the negative consequences of disasters, *"investing in disaster risk reduction"* was defined as one of four priority areas for action over the next 15 years during the World Conference on Disaster Risk Reduction in Sendai, Japan in 2015 (UN, 2015). But while investments into ex-ante disaster risk reduction (DRR) are increasing, they are still dwarfed by ex-post spending in emergency response and recovery, despite evidence for long-term positive gains of investments in DRR.

At the same time, the evidence that risk reduction pays off is growing. In addition to observations from the field, narratives and anecdotal evidence, this includes several reviews of cost-benefit analysis (CBA) for a variety of DRR interventions across different scales, geographies and hazards who find mostly positive CBA ratios (Shreve & Kelman, 2014; Mechler, 2016; MMC, 2020). However, most of these studies do not take into account the probabilistic nature of disasters and that the calculated benefits only materialize in case an event with the magnitude specified in the CBA happens over the lifetime of the DRR intervention (Mechler, 2016). Even after the implementation of a DRR intervention, CBA ratios remain often difficult to calculate due to a missing counter-factual that would allow for a quantification against a hypothetical disaster that the implemented measure was able to prevent (Kron & Müller, 2019). Under austerity and budgets constrains the uncertainty of the "bet" on whether a disaster happens or not over the designed lifetime of an intervention and whether the intervention is able to successfully prevent a disaster makes investments in DRR often to not appear as an attractive business case to decision makers (Tanner et al. 2015, Wright 2016, Fraser et al. 2020).

In the wake of global agreements on disaster risk reduction (Sendai), climate change (Paris Agreement) and sustainable development (SDGs) there is growing recognition that climate adaptation and disaster resilience are not only about preventing negative consequences for economies, human life and livelihoods but can play an important role in supporting sustainable economic development pathways. The idea of broadening the view of DRR interventions beyond their ability to reduce losses and damages by considering their additional economic, ecological and social benefits has therefore been brought forward by several scholars, donor organizations and institutions including the World Bank and the Global Commission on Adaptation (GCA 2019). Including additional benefits of DRR - such as a reduced out-migration as a result of reduced risk levels in a community - in decision making and planning is seen as a promising way to support the creation of a broader business case and to increase the popularity of pre-event investments in DRR.

The concept of frequently overlooked multiple benefits or co-benefits of investments in DRR has been summarized and framed in the literature under the term "resilience dividends"

(Rodin, 2014; Tanner, T. et al., 2015; Vorhies & Wilkinson 2016; Surminski and Tanner 2016). Realizing such resilience dividends is also seen as a key part for a more transformational approach to managing disaster risk including a shift towards more sustainable DRR interventions with a dedicated focus on ecological and social (co-)benefits such as nature-based solutions and ecosystem-based adaptation (Mechler & Hochrainer-Stigler, 2019).

While being an attractive proposition on paper, there is currently only very limited evidence of 'on the ground' applications of the concept of multiple resilience dividends. Challenges arise when applying the concept of multiple resilience dividends to community level DRR projects including (a) a lack of appraisal tools, (b) detailed guidance and what counts as an additional dividend, and (c) which (co-)benefits or dividends can and should be quantified in DRR interventions (Fung & Helgeson, 2017). While first examples for DRR interventions with a dedicated multiple resilience dividend approach are starting to emerge for example under the "triple dividend of resilience" concept advocated by the World Bank and others (e.g. Tanner et al. 2015, GCA 2020), challenges and knowledge gaps on how to consider multiple resilience dividends in planning, implementation as well as monitoring and evaluation of DRR interventions remain.

This paper aims to summarize the state of the art and address the knowledge gaps in terms of a structured analysis of the existing evidence on community level DRR interventions with reported multiple resilience dividends.

We use an innovative analytical approach combining the triple dividend of resilience (TDR) concept developed by Tanner et al. (2015) with the DRR project cycle (e.g., Brent, 1998) to analyse the obstacles in considering multiple resilience dividends in community-level DRR interventions at different stages in their lifecycle. This includes an analysis on how the monitoring and evaluation of multiple resilience dividends of DRR interventions can inform the planning of future interventions. We apply a mixed-methods approach consisting of a global empirical dataset on implemented community-level DRR interventions and in-depth case study analysis of communities in five countries in Europe and Asia.

The remainder of the study is organized as follows: In section 2 we describe the decision-making process for DRR interventions by introducing the DRR project cycle and the TDR concepts. We link the two concepts to an integrated framework that allows us to identify potential entry points for the TDR approach into the lifecycle of DRR interventions and also the challenges that arise from it. We then present two lines of evidence to which we apply our framework to: an empirical dataset based on a survey of NGOs comprising of detailed information of 40 DRR interventions including information on considered resilience dividends, which were implemented in communities in seven countries in Europe, Asia and Latin America as well as five in-depth case study analysis of the planning, implementation and evaluation of individual community based DRR interventions across communities in five countries in Europe and Asia.

We discuss our findings and identify entry points for further research and how these findings can help to facilitate the application of the multiple dividend of resilience concept on the ground to support the demanded shift of ex-post disaster response and recovery spending to investments in pre-event resilience.

2. Decision making on DRR interventions and multiple dividends of resilience

2.1 DRR interventions and multiple resilience dividends

DRR interventions summarize a range of actions and measures that aim to reduce harmful impacts and the risk of displacement while increasing the resilience and overall well-being of communities to be able to cope with disasters (IOM 2020). DRR interventions can be both structural such as levees and reservoirs to reduce the risk of flooding and non-structural such as changes in agricultural practices or education and capacity building to raise awareness for disaster risk and improve preparedness. With the integration of CCA and SD, additional resilience dividends can be considered in DRR interventions that can be defined as the net benefits of a DRR intervention in the absence of a disastrous event (Fung & Helgeson, 2017). These additional resilience dividends can occur as un-intended "side-effects" (e.g. a newly emerging tourism industry from a reservoir originally designed for the purpose of flood and drought management) during or after the implementation or can be intentionally included in the appraisal and/or planning of DRR interventions (e.g. a tsunami shelter that is designed to be also used as a community centre) (Fung & Helgeson, 2017). Both intended and un-intended additional resilience dividends of DRR interventions are considered in this study (see Figure 1). Together with the resilience dividend that materializes in the case of a disastrous event they form the multiple dividends of resilience of DRR interventions.

2.2 Linking the evidence base on materialized multiple dividends of resilience to appraisal tools and frameworks

The evidence base on multiple resilience dividends in DRR interventions is sparse and fragmented. Two strands of literature have evolved over the last years: case studies in both the academic and grey literature reporting empirical or anecdotal evidence on multiple resilience dividends of DRR interventions often in the context of co-benefits of ecosystem-based adaptation and nature-based solutions (McVittie et al, 2018, Tomczyk et al. 2016) as well as an emerging strand of literature describing tools and approaches for a structured consideration of multiple resilience dividends in the planning and appraisal process of DRR interventions (Fung & Helgeson, 2017; Fung et al. 2020). The latter includes different variations of multi-criteria analysis (Wardekker et al., 2016; Scrieciu et al., 2014), extensions of cost benefits analysis to include social welfare implications (Herrero et al.,2013) as well "pathway analysis" that aim to estimate multiple resilience dividends of an intervention over time compared against a baseline scenario (RAND, 2018)

The type and sophistication of the reported evidence on multiple dividends of resilience varies considerably between studies and fall into three categories: in the majority of the available literature, multiple dividends of resilience are only qualitatively considered or mentioned in the context of a DRR intervention but are not formally included as part of the planning process and/or the monitoring and evaluation of an intervention (Vorhies & Wilkinson, 2016; Surminski and Tanner 2016; Tanner et al. 2015). A second group of studies aim to formally include multiple resilience dividends in the planning process including a formal appraisal based on assumptions of the expected net benefits, that were not informed by empirical evidence due to a lack of suitable data (RAND 2018, Fung et al. 2020). The third category only consists of very few studies that use quantified evidence on multiple dividends of resilience of DRR interventions. Either as part of an ex-ante appraisal using quantitative evidence from

previous studies or by quantifying resilience dividends as part of an ex-post valuation of already implemented interventions (Fung & Helgeson 2017, Mechler and Hochrainer, 2019). Especially quantified evidence on multiple resilience dividends of DRR interventions is increasingly demanded by scholars, practitioners and donor organizations as it is seen as one of the key steps in both substantiating the high level narrative of multiple resilience dividends for advocacy and to inform the design of DRR interventions on the ground. However, the quantified evidence base on materialized multiple dividends of resilience for DRR interventions is currently still lagging behind the underlying concepts and narratives.

One reason for this lag are the different time frames for different resilience dividends to materialize (Reyers et al. 2015). While some dividends may materialize almost immediately after the intervention has been implemented and can be measured and quantified shortly after (e.g. weather forecasting systems to improve early warning and farming practices), others can take years (e.g. restoration of mangrove forests) or decades (e.g. stopping long-term out-migration) to become evident. This makes it difficult to obtain empirical evidence on the full range of resilience dividends of DRR interventions as it requires ex-post valuations of DRR interventions decades after their implementation.

In addition, there are currently no agreed standards on how multiple resilience dividends can be considered in the planning and design stage for an DRR intervention, to allow for an unambiguous valuation and monitoring of their successful implementation, needed to better inform future projects.

This paper aims to strengthen the link between the described stages of the DRR project lifecycle of DRR interventions by providing an integrated framework that allows to analyse current challenges and shortcomings for different types of resilience dividends during the design, deployment as well as monitoring and evaluation of multiple resilience dividend DRR interventions.

We use this framework to 1) explore how data on community level DRR interventions can support the planning and design stage of DRR interventions to create multiple resilience dividends 2) analyse five different case studies in which different multiple resilience dividends were considered, estimated and quantified at different stages during the decision-making cycle for community DRR interventions.

2.3 An analytical approach for multiple dividends of resilience in the

The process of implementing a DRR intervention comprises of several steps, which are more or less formalized depending on the context. The disaster risk reduction and adaptation literature has identified various frameworks that propose a number of steps to be sequentially carried out. Brent et al. (1998) and Mechler (2016) identified seven steps starting from the identification of the objectives and the problems that should be addressed with the intervention to the monitoring and evaluation stage, where the short-and long-term outcomes are evaluated against the initially set objectives.

For the net-benefits or dividends of a DRR intervention we distinguish between three different types of resilience dividends following the concept by Tanner et al. (2015): a first dividend accounts for the avoided losses and damages in case of a disaster. The second and third

dividends account for net-benefits of DRR interventions that materialize regardless of a disaster, where the second dividend accounts for the economic potential of a community that is unlocked through the intervention and the third dividend describing other development co-benefits.

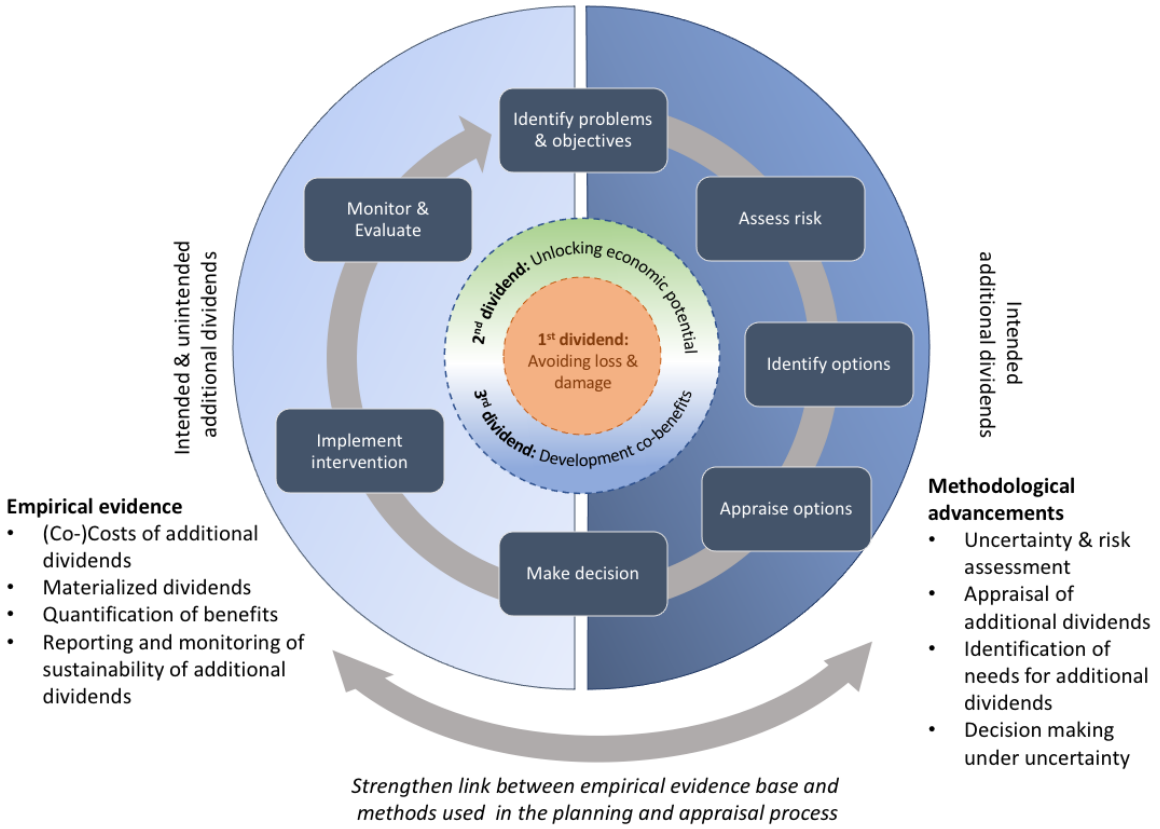

Figure 1: Integrated framework for considering resilience dividends along the lifecycle of DRR interventions.

By intersecting the lifecycle of DRR interventions with the TDR concept, we analyse how first, second and third dividends are considered at the different stages of a project and how they influence the outcomes in community level DRR interventions (Figure 1). As shown in Figure 1 the TDR concept fulfils different functions at the different stages of the lifecycle. In the stages leading to the decision for a particular DRR intervention, the TDR concept informs the decision making process by helping to recognize and appraise the full range of benefits a specific intervention option has (Figure 1 – left). This means, the main function of the 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 for different DRR intervention options. For the stages after the decision for a specific intervention was made (Figure 1 – right), the main function of the TDR concept is to (a) ensure that an DRR intervention is implemented in a way that multiple resilience dividends can materialize and (b) guide the monitoring and evaluation process so the multiple resilience dividends that have been identified in previous stages are evaluated against their pre-defined targets. During the evaluation the different resilience dividends can be empirically quantified and provide crucial information needed to inform future DRR intervention projects, facilitating an iterative learning process on how to best realize multiple resilience dividends.

We apply this framework to analyse two different datasets: An empirical dataset of different resilience dividends considered by different NGOs during their planning and implementation stages and a set of detailed DRR case studies covering multiple resilience dividend interventions at different stages of the project lifecycle across different geographies and contexts. We use the two different analysis to improve the understanding on how additional dividends are considered and how this influences the outcomes of the DRR intervention.

3. Methods: Two lines of evidence for comparing multiple resilience dividends across communities in twelve countries

3.1 Survey of implemented DRR interventions across communities in eight countries

Data on implemented community-level DRR interventions were collected through a structured survey among three non-governmental organizations (NGO) involved in community level DRR work as part of the Zurich Flood Resilience Alliance (ZFRA). The NGOs were asked details on the communities they are working in, the interventions they have been implemented together with the communities as well as details on the interventions, outcomes and the current status of the intervention.

The questions in the survey were a mix between closed and open questions. Based on the open answers providing detailed descriptions of the planning and implementation of each intervention, the interventions were clustered into six different types distinguishing between structural and non-structural interventions: *Agricultural* interventions, cover interventions that involve changes in agricultural practices with the goal to both increase food security in case of a disaster and improve livelihoods of agricultural communities otherwise. *Capacity building & Education* covers interventions that aim to improve the DRR knowledge of community members and improve the disaster preparedness of communities. *Forecasting & Early Warning Systems (EWS)* cover technological interventions that provide information that allow to prepare for a disaster. *Livelihood & Finance* describe non-structural interventions that aim to improve the disaster resilience of communities by using financial instruments such as insurance or saving schemes. *Water management & Hygiene* covers intervention that aim to prevent health and hygiene issues that often come with disasters.

Following the framework presented in Section 2.2, the expected outcomes of each intervention reported by the NGOs were categorized according to the three different resilience dividends. The resulting dataset covers 40 different types of interventions that were implemented in 91 communities[1] across eight countries in Asia, Europe and Latin America: Bangladesh, El Salvador, Mexico, Montenegro, Nepal, Nicaragua, Peru and Philippines (see Figure 2- countries marked in blue). The questionnaire used in the survey as well as the underlying data can be found in the Appendix.

[1] Identical DRR interventions have been implemented in multiple communities and therefore the number of individual interventions is lower than the number of communities they have been implemented in.

3.2 A comparative analysis of community case studies to understand the challenges of multiple dividends of resilience in DRR interventions on the ground

In addition to the empirical analysis on multiple dividends of resilience in DRR interventions, described in the previous chapter, a comparative forensic analysis of five different case studies is performed to get insights into approaches, challenges and obstacles when considering multiple resilience dividends during planning, implementation, monitoring and valuation of DRR interventions. The five case studies have been selected to cover different geographies, types of measures, approaches, implementation stages and supporting environments (see Figure 2). The case studies cover all stages along the decision making cycle in conjunction with their different resilience dividends. In total reports of four non-governmental and one governmental organization were selected based on the quality and level of detail of the provided information covering communities in Vietnam, Indonesia, UK, Afghanistan and Nepal. Case study 1 (Vietnam) covers the decision-making process from the identification of the problem and objectives to the actual decision for a specific DRR intervention. Case studies 2 (Indonesia), 4 (Afghanistan) and 5 (Nepal) additionally include the implementation stage. Case study 3 (UK) focuses on the monitoring and evaluation stage of an already implemented DRR intervention. Based on the framework presented in section 2.2 a set of guiding questions were prepared to structure the analysis of the case studies. The data collection was performed through a desk research analysing project and organizational reports of governmental and non-governmental organizations responsible for the implementation of community DRR interventions.. The available information was validated and enhanced through interviews with key informants that were responsible for the deployment of the respective DRR interventions in the five communities. The case studies are structured in three parts: a short background section describing the type of DRR intervention and the context it was implemented in; a section describing which resilience dividends were considered and how; and a third section describing the identified challenges and knowledge gaps. The underlying guiding questions for this analysis can be found in the Appendix.

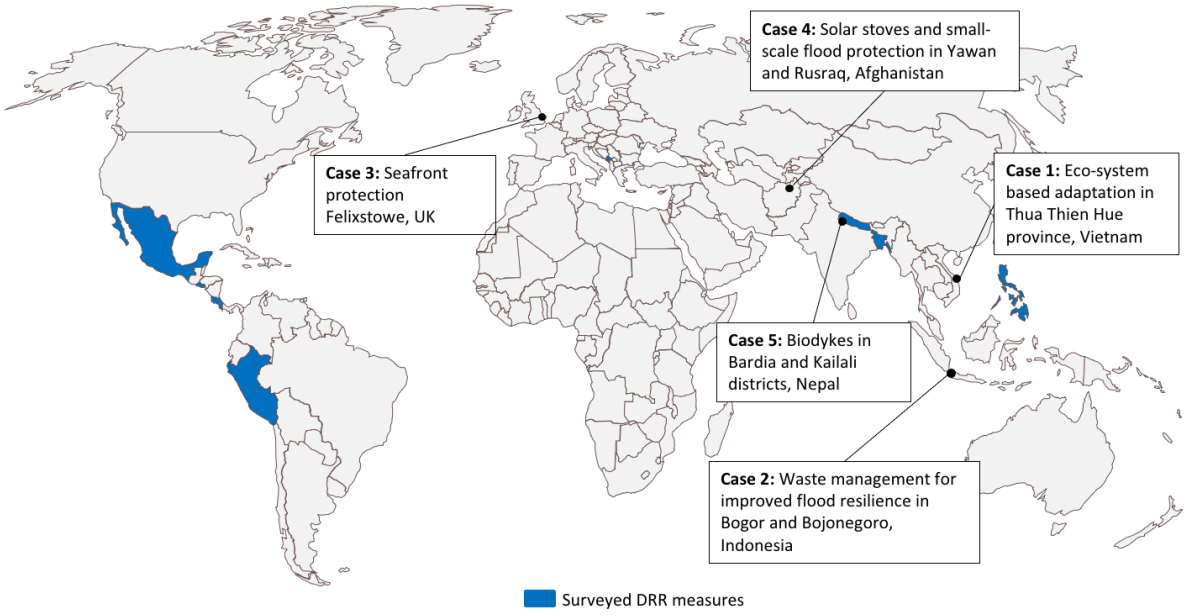

Figure 2: Overview case study locations and countries in which community surveys of DRR measures were conducted (countries shown in blue).

4. Findings

4.1 Survey of additional benefits of implemented DRR interventions

In total 40 individual DRR interventions across eight countries were surveyed. Nearly 60% of the interventions were implemented in Mexico and Central American countries (El Salvador, Nicaragua), 20% in Bangladesh and 20% in four other countries in South America (Peru), Europe (Montenegro) and Asia (Nepal, Philippines) (Figure 2). The most common types of implemented interventions are *Capacity building & Education* (39%), *Water management & Hygiene* (22%), *Forecasting & EWS* (14.6%), *Agricultural* (12.2%) and Livelihood & Finance (7%) interventions. The surveyed DRR interventions are mostly small scale with setup costs between USD 85 and USD 41,700 (median USD 905), implemented in vulnerable rural communities.

Figure 3 shows for different groups of DRR interventions, which of the three resilience dividends (1st dividend: avoiding losses and damages, 2nd dividend: unlocking economic potential, 3rd dividend: development co-benefits) have been considered for the individual interventions. The *Capacity building & Education* (94%) as well as *Forecasting & EWS* (100%) and *Water management & Hygiene* (78%) sub-groups have the highest share of interventions expected to avoid losses and damages (1st dividend). This includes DRR interventions that aim to reduce losses and damages through changing behaviour of individuals (such as safe storage of valuable items and safety training to reduce injuries in case of a disaster), explaining the high number of DRR interventions with 1st dividends in the *Capacity building & Education* group. *Forecasting & EWS* have a clear focus on avoiding losses and damages with all of the survey measures aiming to contribute to the 1st dividend, but some also come with additional development co-benefits such as improved agricultural practices through more accurate weather information. Only 20% of the DRR interventions in the *Agricultural* group are considered to avoid losses and damages. However, all DRR interventions in the *Agricultural* group (100%) are designed to unlock the economic potential of the communities they have been implemented in (2nd dividend). Such interventions often aim to increase productivity to move from subsistence to small hold farming creating additional economic opportunities for rural communities.

The group of DRR interventions with the highest share of interventions expected to have development co-benefits (3rd dividend) are *Agriculture* (80%), *Livelihood & Finance* (67%) as well as *Water management & Hygiene* (89%). Those benefits are not directly leading to economic opportunities but increase the overall welfare of communities such as through cleaner air and water resources, improved waste management or improved food security.

While no individual DRR intervention in the survey was reported to have all three resilience dividends, most notable none of the DRR interventions in the *Livelihood & Finance* group are expected to directly avoid losses and damages. However, 50% of all reported interventions in that group reported to have 2nd and 3rd resilience dividends. This can be explained by the main focus of *Livelihood & Finance* interventions to support financial and economic stability of communities that would be resilient to climate risk related shocks. On the question whether the reported DRR interventions have been previously implemented in a community, the NGOs answered that 46% of the implemented DRR interventions are adapted interventions that they had been previously implemented in other communities, 29% were exact replications of interventions the respective organization had previously implemented in other communities and 18% were completely new interventions to that NGO.

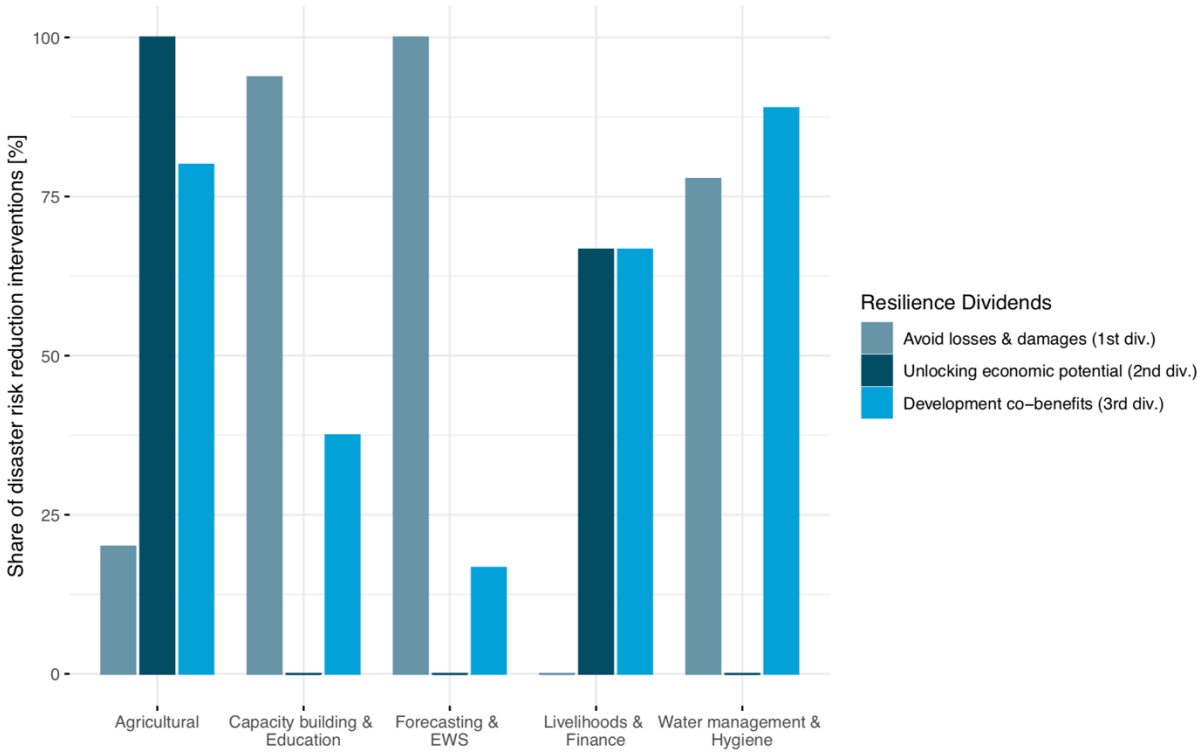

Figure 3: Individual resilience dividends for five different groups of DRR interventions: Agricultural, Capacity building & Education, Forecasting & and Early warning systems (EWS), Livelihood & Finance and Water management & Hygiene. The bars show the percentage of DRR interventions that have considered 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 have considered this resilience dividend). Total number of survey DRR interventions N = 40.

4.2 Findings from the case studies

Table 1 provides a summary of all case studies including a short description of the DRR interventions and its context, the covered steps of the decision making process, the considered resilience dividends, methods and approaches used as well as potential challenges. Table 2 provides a detailed summary of each dividend that was considered in the individual case studies grouped by the three types of resilience dividends as described in section 2.3.

Table 1: Summary of case studies

Case 1: Eco-system-based adaptation Thua Thien Hue province, Central Vietnam	
Intervention:	Planting mangroves to reduce wave energy and coastal erosion & restoration of urban water bodies to reduce risk of surface water flooding
Decision making stage(s)	Identify problems and objectives, Asses risk, Appraising options, Make decision
Considered dividends:	Reduced damages and loss of life from flooding (1st div.), new habitats for fisheries for improved livelihoods and tourism (2nd div. mangroves); support small local businesses through increased recreational value (2nd div. pond restoration); increased participation of women in local DRR and CCA decision (3rd div.)

Approach:	Quantitative surveys (impact of floods and ecosystem services on well-being); willingness to pay (WTP) analysis; cost-benefit analysis (CBA) for individual dividends
Challenges:	Skepticism among local decision makers on efficacy of EbA for risk reduction; perception of usefulness of additional benefits biased by personal values of local decision makers

Case 2: Waste management for flood resilience Bogor & Bojonegoro, Indonesia

Intervention:	Introduction of a community waste management system including setup of recycling facility to prevent flooding from blockings caused by garbage disposal in the river
Decision making stage(s)	Identify problems and objectives, Assess risk, Appraise options, Make decision,
Considered dividends:	Prevent frequent flood damage in communities (1st div); create new opportunities for livelihoods by creating handicrafts from recycled material (2nd div); use compost as organic fertilizer (3rd div)
Approach:	Community flood resilience assessment; CBA to estimate if additional revenue from recycling can cover costs of recycling facility
Challenges:	No specific challenges reported but success of intervention largely depends on behavioral change on waste management of local population

Case 3: Seafront protection Felixstowe, UK

Intervention:	Rock groynes to protect urban seafront from coastal erosion and increase in flood risk from sea level rise for the next 100 years
Decision making stage(s)	Monitor and evaluate
Considered dividends:	Reduce flood damage to properties, commercial enterprises, recreational areas and key infrastructure (1st div); creation of new jobs through restoration of hotels and other services, significant increase in visitors (2nd div); increase of annual revenue by local authority through visitor parking and accommodation (2nd div.); Increased recreational value through seafront restoration (3rd)
Approach:	Formal CBA for risk reduction against a "do-nothing" scenario; ex-post attribution of increased job opportunities and additional local authority revenue from intervention
Challenges:	Lack of formal appraisal and M&E approaches for additional resilience dividends; unclear which resilience dividends can and should be quantified; applying for multiple resilience dividend projects complicated through co-funding requirements

Case 4: Solar stoves and small-scale flood protection in Yawan & Rusraq, Afghanistan

Intervention:	Small-scale flood protection using local knowledge and materials; mainstreaming flood risk management (FRM) in community development planning; solar stove technologies for food and water security & reduced wood chopping
Decision making stage(s)	Identify problems and objectives, Assess risk, Appraise options, Make decision,
Considered dividends:	Reduced flood risk (directly through small scale flood protection and improved FRM, indirectly through improved water retention from reduced wood chopping) (1st div.); improved economic possibilities for women and girls through safer and more efficient cooking (2nd div.); improved food and water security, more sustainable use of local resources (3rd div.)
Approach:	Flood resilience assessment to identify resilience strengths and weaknesses of the communities; participatory CBA
Challenges:	Long timeframes for materialisation of additional resilience dividends (e.g. effects from solar stoves on flood risk reduction); long-term M&E processes necessary

Case 5: Biodykes in Bardia and Kailali districts, Nepal

Intervention:	Construction of biodykes (banks built from local materials, stabilized by vegetation growing on them) to reduce bank erosion and flooding of agricultural areas
Decision making stage(s)	Identify problems and objectives, Assess risk, Appraise options, Make decision,
Considered dividends:	Reduced flood damage to agricultural land (1st div.); increase in agricultural yields (avoided damage and new crops growing on the biodyke); lower outmigration (2nd div.); CO_2 sequestration and new wildlife habitats (3rd div.)
Approach:	Semi quantitative cost-benefit comparison between biodykes and conventional flood walls
Challenges:	Lacking support for biodykes from local decision makers due to longer timeframes for risk reduction; conflict over uneven distribution of resilience dividends among the community

4.2.1 Eco-system-based adaptation Thua Thien Hue province, Central Vietnam

4.2.1.1 Background

As part of a DRR and research project by the Global Resilience Partnership, eco-system-based adaptation (EbA) measures have been planned and implemented in the Giang Lagoon, Bu Lu river delta and Hue City (Bubeck et al., 2019). The region suffers from flooding from river, sea and from heavy rainfall mainly during monsoon season. Between 1975 and 2005 40 flood events were recorded in the region (Bubeck et al. 2012). At the same time the province highly depends on eco-system services of the surrounding water bodies including 100,000 people directly relying on the lagoon as fishing grounds and for their water supply (Van Tuyen, 2010). In UNESCO listed Hue City the local ponds act as retention areas in case of heavy rainfall events, while at the same time are important for local tourism and recreation. Population growth and rapid urban expansion has led to a fast disappearance of natural areas putting additional pressure on the available ecosystem services while at the same time increasing the exposure to flooding. Apart from that, a gender gap between men and women was identified as one key issue of the communities' flood resilience: as main care givers in the community to both the elderly and children, women have limited mobility in case of a flood disaster and also less opportunities to build up savings for a fast financial recovery.

4.2.1.2 Consideration of resilience dividends

With a focus on the most vulnerable parts of the community, who directly depend on fisheries as food source as well as tourism as additional income, EbA was identified as suitable DRR intervention in the planning and appraisal stage as EbA both supports ecosystem services and protects from flooding. Three measures were implemented: planting mangroves at the Tam Giang Langoon and Bu Lu river to reduce wave energy and coastal erosion while at the same time provide habitats for fisheries, restoration of urban water bodies in Hue City to reduce risk from surface water flooding through improved drainage while improving the recreational value of the ponds important for small local businesses related to tourism. A third measure were communication campaigns to raise awareness for flood resilience and EbA among the local population. Additional resilience dividends have been intentionally considered already in the planning process including a second dividend through anticipated increase in tourism and improved livelihoods from fisheries. During the implementation process additional, un-intentional resilience dividends were recorded including an increased participation in the planning and decision-making processes around DRR and CCA by women through an active engagement in the 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 have been used to quantify or define additional dividends. This includes quantitative surveys

of flood prone households as well as domestic and international tourists, analysis of self-assessed well-being to examine impacts of floods and ecosystem services on individual welfare and willingness to pay analysis for different resilience dividends (reduction of damage, seafood , increase in tourism). CBA was used to quantify the benefits of the different dividends. In all cases additional dividends have contributed to the positive CBA ratios (benefit to cost ratios: 2.3 for mangroves reforestation, 34 for pond restoration) and in case of the pond restoration second and third dividends were already resulting in positive CBA rations.

4.2.1.3 Challenges and knowledge gaps

While the project was initially designed as an EbA project with additional resilience dividends, the lack of previous experience with EbA and what additional benefits can come with it, lead to skepticism among local decision makers. Especially regarding the effectiveness on EbA for the first dividend and how and when additional benefits would materialize. A survey among local decision makers revealed a mismatch between already existing national government strategies on connecting EbA with CCA and DRR and knowledge of local decision makers (Wolf et al., 2020). Perception of additional benefits and their usefulness for the community was often biased by the personal values of local decision makers and how long-term conservation should be balanced with immediate economic needs. Due to the long timeframes until ecosystems start delivering services, local decision makers saw EbA more suitable as long-term strategy. Successful pilot projects already implemented elsewhere were reported to help to better communicate the additional benefits to local decision makers.

4.2.2 Waste management for improved flood resilience in Bogor and Bojonegoro, Indonesia

4.2.2.1 Background

The villages Bogor and Bojonegoro (pop. 16,1000) are rural/semi-urban communities south of Jakarta and are a popular weekend destination for inhabitants of the Indonesian capital. The biggest part of the local economy evolves around tourism. The communities are frequently affected by flooding (four times alone in 2015) from the Ciliwung river. Other hazards include landslides, as well bio-hazards, air pollution and contamination associated with the 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 also identified garbage disposal as main reason for the increased flood hazard as 70% of households reported to dump their garbage into the river which causes blockings that lead to flooding (IFRC, 2017, Laurien & Keating 2019). The blockings and subsequent flooding also affect the communities downstream.

4.2.2.2 Consideration of resilience dividends

Based on these findings a local waste management system was found to be the most suitable approach to reduce the flood risk and subsequent damage in the communities (1st dividend). As part of the planning process 2nd and 3rd dividends were considered: using recycled materials to create handicrafts was proposed as a way of creating new opportunities for livelihoods (2nd dividend) and the compost can be used as organic fertilizer (3rd dividend). A particularity in the consideration of additional dividends is that the upfront investment and running costs of the recycling facility are planned to be fully covered by the revenue stream created 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 society 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 on the national level were not involved. Risk assessments have been conducted only qualitatively, but a implicit CBA was performed to estimate if waste recycling can cover costs of the recycling facility.

4.2.2.3 Challenges and knowledge gaps

While no specific challenges were reported from the planning and implementation phase the materialization of all three dividends depend to a large extent on behavioural changes on waste management of the local population. One particularity on this case is that some additional dividends can be realized almost immediately after the implementation as the supply chain for recycled waste and revenue streams have been set up in the planning stage and have been the condition for setting up the recycling facility.

4.2.3 Seafront protection Felixstowe, UK

4.2.3.1 Background

The town of Felixstowe is an urban area on the east coast of England with a population of 24,000 and has the largest container harbour in the UK. Felixstowe is mainly affected by flooding from sea and coastal erosion which is expected to increase due to sea level rise and increase in storms. In order to protect properties, commercial enterprises and amenity beaches, recreational gardens and key infrastructure along the sea front a project approval request for flood protection infrastructure was developed to obtain funding from the Environment Agency, the national body responsible for flood risk management. The aim is to manage the flood risk along the sea front for the next 100 years. Risk assessments estimated 1,491 properties and critical infrastructure would be affected by coastal erosion with a projected total loss of GBP 148.3m in a "do-nothing" scenario. A CBA with the preferred option of straight rock groynes resulted in a benefit-cost-ratio of 11.3.

4.2.3.2 Consideration of resilience dividends

While no additional dividends have been formally considered in the planning and implementation stage, multiple resilience dividends were recorded as part of the monitoring and valuation process of the intervention five years after its completion. For the second dividend, the increased protection from the new flood defences stimulated new investments in the property sector including the construction of a new hotel creating 25 new jobs and the restoration of two existing hotels, which have previously been in decline. Together with additional investments in the housing sector and investments in the amenities, the seafront was fully restored with a positive effect on retail and business. A significant increase in visitors was recorded between 2012 and 2015 of which around 50% can be attributed to the new flood protection scheme. Another second materialized second resilience dividend that could be attributed to the DRR intervention was an increase of annual local authority revenue of GBP 283,680 from parking and seafront visitor accommodation. Third dividends in the shape of an increase in recreational value and attractiveness of the restored seafront was only party quantified in terms of an increase in visitor numbers. The assessment and retrospective evaluation of additional resilience dividends by the Coastal Partnership East (CPE), a group of local authorities, as part of the monitoring and valuation stage was done to support the business case for similar projects and future interventions. CPE developed a matrix system to

include both quantitative measurements and qualitative assessments of additional resilience dividends that materialized three years after completion of the DRR intervention.

4.2.3.3 Challenges and knowledge gaps

A main challenge was the lack of both appraisal and monitoring and evaluation frameworks that help including additional resilience dividends in the planning process and defines what can and need to be quantified during monitoring and evaluation. It also remained unclear what additional dividends funders would accept or take into account for future decisions on funding applications. Applying for explicit multiple resilience dividend projects is additionally complicated through the need for additional co-funding in case additional resilience dividends and co-benefits are explicitly included in a proposal that do not specifically aim at reducing losses and damages (EA, 2018).

4.2.4 Solar stoves and small-scale flood protection in Yawan and Rusraq, Afghanistan

4.2.4.1 Background

The Yawan district in eastern Afghanistan is a mountainous region with a population of around 13,000 people. After civil unrest for many years over 50% of the Afghan population lives below the poverty line and Afghanistan has one of the lowest human development index rankings globally. Floods are the most common natural hazard in the country affecting approximately 100,000 people each year. The largest share of the population in the Yawan district are poor farmers, practicing unsustainable cultivation on marginal land prone to extreme weather. 70% of people depend on agriculture for their livelihoods, and almost 70% are living below the national poverty line. Flash floods and mudslides frequently block roads, making communities inaccessible to vehicles. All communities in this case study were impacted by an extreme flood event in the last 10 years. Concern Worldwide together with the local communities has conducted a flood resilience assessment and a participatory cost-benefit analysis to identify potential DRR interventions. Based on the identified weaknesses regarding an underinvestment in critical infrastructure such as roads in combination with a high human capital, a combination of three interventions were identified: 1) small scale flood risk protection infrastructure using existing community knowledge, sourced from local materials and managed by community disaster committees. 2) Mainstreaming flood risk management into community development planning, to ensure that flood risk is included by Community Development Councils and 3) Solar stove technologies for food and water security, gender equality and environmental sustainability (Laurien & Keating 2019). The implementation of the measures were supported by several government entities including the National Disaster Management Authority (ANDMA) and the Directorate of Rural Rehabilitation and Development (DRRD), who are monitoring the flood protection structures.

4.2.4.2 Consideration of resilience dividends

While flood risk was a key concern, the resilience dividends that were considered in the planning process were equally focussing 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 in case the second (safer and more efficient cooking allows for more economic possibilities) and third dividends (improved food and water security, more sustainable use of local resources) materialize: the communities in this region are highly 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 woodfire stoves removes local vegetation and thereby increases flood risk.

4.2.4.3 Challenges and knowledge gaps

Since materialization of first dividend directly depends on a successful materialization of second and third dividends it means that DRR component of the intervention will materialize long after the development and CCA component. In order to evaluate success a long-term monitoring and evaluation approach is necessary. This information is generally difficult to obtain given the short period of developing projects.

4.2.5 Biodykes in Bardia and Kailali districts, Nepal

4.2.5.1 Background

The Bardia and Kailali districts lie in north western Nepal on the border to India. The two communities in Bardia and Kailali consist of 135 and 60 households respectively. In both cases the main livelihood of community members is agriculture, which is also the key source for their food security. The majority of the agricultural land is highly susceptible to regular flooding of tributaries of the Karnali river during the monsoon season, destroying crops, putting livestock at risk and leaving 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 bio-dykes to reduce bank erosion and loss of agricultural land during flooding as well as to save lives and properties. Faced with more frequent and intense climate induced disasters, bio-dykes have emerged as a DRR intervention that can be well integrated into local plans and community led programmes across the different geographic areas in Nepal. Bio-dykes are a bio-engineering solution that can control bank erosion and control flood risk by mediating the water flow through a combination of vegetation and structural measures. The vegetation controls the erosion of an embankment built from locally available material such as sand, rocks and soil. In the initial stage sand bags are used to control erosion while the biological measures gradually become more effective when plants mature and their roots start to stabilize the soil. For the vegetation local grass, shrub and tree species are used. Bio-dykes with a length of 220 and 1500 meters were built in the two communities coordinated by the Local Disaster Management Committee.

4.2.5.2 Consideration of multiple resilience dividends

The main motivation for implementing bio-dykes instead of hard resilience measures such as concrete flood walls, were the lower construction and maintenance costs. The difference in costs was quantified through a cost-comparison between the two measures resulting in bio-dykes being around two times cheaper compared to an equivalent measure made from concrete walls, mainly due to lower maintenance costs, which can be undertaken by members of the community in the case of bio-dykes. In addition, second and third dividends were considered qualitatively as part of the planning process. As second dividend an expected increase in agricultural yield (both through avoided losses and damages to existing crops and livestock as well as by creating new forest products from bio-dyke materials such as fodder and fuel wood) and lower out-migration through increased opportunities in the community were considered. Third dividends included CO2 sequestration and the creation of new wildlife habitats as co-benefits of the planned bio-dykes.

4.2.5.3 Challenges and knowledge gaps

Despite the higher costs and lower potential for multiple resilience dividends, local decision makers as well as members of the community were in favour of concrete walls or comparable hard resilience measures. The main reason for supporting the latter was due to concerns about the slow materialization of the resilience dividends especially in regard to the first dividend as the vegetation on bio-dykes need to be mature to deliver full protection from flooding while concrete walls offer the designed protection right after their implementation. The focus on the first dividend and as a consequence, the preference of hard resilience interventions by the local community highlighted knowledge gaps and mismatches between national level policies and local level implementation. The preference for concrete walls remained the favoured option by local community members also after the implementation of the bio-dykes as they questioned the efficiency of the intervention in avoiding losses and damages. On the national level policies actively encourage nature-based solutions and see them as superior compared to hard resilience measures as they align DRR with CCA activities, deliver additional benefits and were found to be more cost-efficient. Since its implementation in 2015 the bio-dykes were reported to efficiently prevent river bank erosion and also avoided flooding of one of the communities including sand deposits on agricultural land. While so far of the intended additional resilience dividends especially an increase in fodder for livestock has been materialized, local communities have also reported new knowledge and skills as a valuable additional benefit, which has not been initially been considered in the planning stage. On the other hand, also a number of unintended disadvantages and co-costs were reported such as wild animals hiding in the bio dykes and destroying crops and conflict over plant resources grown on the bio-dykes.

Table 2: Summary of resilience dividends considered in the five different case studies

	1st dividend: Avoiding losses and damages	**2nd dividend: Unlocking economic potential**	**3rd dividend: Development co-benefits**
Eco-system-based adaptation, Vietnam	• Reduced damages to fishing boats from coastal flooding • Reduced coastal erosion • Reduced damages of residential homes and businesses in urban areas	• New habitats for fisheries for improved livelihoods and tourism • Support small local businesses through increased recreational value	• Increased participation of women in local DRR and CCA decision
Waste management, Indonesia	• Prevent frequent flood damages in the community • Reduce flood damages in downstream communities	• Create new opportunities for livelihoods by creating handicrafts from recycled material	• Use of compost as organic fertilizer
Seafront protection, UK	• Reduce flood damage to: -residential properties -commercial enterprises, -recreational areas -key infrastructure	• Creation of new jobs through restoration of hotels and other services • Increase in visitors • Increase of annual revenue for local authority from taxes and fees	• Increased recreational value through seafront restoration
Solar stoves and small scale flood	• Direct flood risk reduction of through small scale flood	• Improved economic possibilities for	• Improved food and water security

protection, Afghanistan	protection and improved FRM, • Indirect flood risk reduction through improved water retention	women and girls through safer and more efficient cooking	• More sustainable use of local resources (fire wood, drinking water)
Bio-dykes, Nepal	• Reduced flood damage to agricultural land	• Increase in agricultural yields (incl. new crops growing on biodyke) • Lower outmigration	• CO_2 sequestration through vegetation growing on bio-dykes • New wildlife habitats

5. Discussion

The study's approach in analysing multiple dividends of resilience along the decision-making cycle reveals general as well as context specific challenges and knowledge gaps among the investigated community DRR projects in different countries. The analysis shows that in the analysed developing countries high-level policies (mostly on the national level) that align the DRR, CCA and development are already in place and (at least in theory) provide the necessary legal frameworks to consider multiple resilience dividends in community DRR projects (see case studies from Vietnam, Nepal and Afghanistan). This development is driven by both budget constraints and the often immediate development needs in the vulnerable communities.
The UK case study as an example shows that in the developed world institutional silos are more prevalent and DRR is traditionally seen as a singular task with the goal to avoid losses and damages. Attempts to break through these silos to deliberately include multiple resilience dividends in the intervention planning and appraisal were found to be further complicated due to separate funding sources and funding bodies for DRR, CCA and community development (see UK case study). Keating & Hager-Kopp (2020) also find lacks in integrating resilience concepts in funding programs in developing countries, while a more advanced integration of DRR and CCA in national policies in the developing world is in line with findings by Fung & Helgeson (2017).

However, the more integrated policies in the developing world are often counteracted by a high level of scepticism and concerns about the multiple resilience dividend approach. Multiple resilience dividend interventions often come as new and innovative solutions such as ecosystem-based adaptation (Vietnam) or nature-based solutions (Nepal), which can yield higher additional resilience dividends compared to more conventional approaches (such as flood walls), but often have higher design uncertainties when and if dividends materialize as their success depends on a larger number of additional factors (Onuma & Tsuge, 2018). In all cases, measures were implemented on the back of a recent disaster, which increased pressure on local decision makers to act quickly on reducing the risk of future losses and damages, further amplifying concerns that the efficacy in reducing losses and damages is sacrificed for higher second and third dividends (Bubeck et al. 2020).

Local- decision makers in Nepal and Vietnam acknowledged that there are trade-offs between the speed and effectiveness a DRR intervention is able to reduce losses and damages and the long-term benefits of additional resilience dividends from DRR interventions for their communities. This led to the believe of local decision makers in the two communities, that the implemented multiple resilience dividend interventions are likely to be more beneficial for their communities in the long run, but interventions that have the sole purpose of reducing losses and damages (such as concrete flood walls) and potentially lower additional resilience

dividends are able to offer faster and more efficient protection and should be the preferred option in cases where a quick risk reduction is necessary.

This is also closely linked to the perceived usefulness of the additional resilience dividends by local decision makers and whether those additional dividends are meeting the needs of their communities. The case study on bio-dykes in Nepal showed that despite materialized resilience dividends such as additional forest products and CO_2 sequestration, also unexpected co-costs emerged such as conflicts around new resources and newly settled wild animals destroying yields, lowering the perceived benefits and overall acceptance of the intervention. One way to increase the perceived usefulness and acceptance by local decision makers is to only formally include the resilience dividends that benefit the local community and exclude global benefits such as CO2 sequestration from the planning and appraisal stages as done in the Vietnam case study (Bubeck et al, 2019).
Scepticism towards DRR interventions with multiple resilience dividends such as ecosystem-based adaptation is also fuelled by personal values and knowledge gaps from decision makers as a survey by Wolf et al. (2020) for the case study in Vietnam revealed.

One approach that was found to be successful in overcoming high levels of scepticism and to close knowledge gaps are successfully implemented pilot projects elsewhere that were able to generate convincing evidence on materialized resilience dividends of a proposed intervention that helped communities in their development.

However, reported evidence from implemented pilot projects are currently rare, partly due to missing approaches and frameworks that allow for including multiple resilience dividends first in the planning stages and to later report on their materialization as part of the monitoring & evaluation stage (see Figure 1). In order to make progress in realizing multiple resilience dividends in community DRR interventions and to align targets from high level policies with work on the ground further steps are necessary. Integrated decision making frameworks on multiple resilience dividends need to be established and need to consistently cover the entire decision-making cycle to be able to both consider multiple resilience dividends early on in the planning and appraisal process and to follow each considered resilience dividend throughout the implementation and materialization stages.

The results of the quantitative analysis of community DRR measures in Section 4.1 showed that there is no “silver bullet” intervention that can solve all issues identified by a community at once through multiple resilience dividends. Most notably some types of measures do not directly contribute to avoiding losses and damages, although contributing to a lower disaster risk of a community e.g. through the increased financial resilience of households.

Future tools and approaches need to acknowledge that: instead of maximizing resilience dividends based on a specific metric (e.g. monetary benefits) decision making approaches need to identify and generate those dividends that are most needed and demanded by the community. Combining the structured approach of the multiple dividends of resilience (for example through the TDR approach presented in this paper) with a participatory decision-making process can help creating “tailored” multiple resilience dividend solutions according to the needs identified by the community. This would mean a shift from the current practice of single goal CBA analysis in which one main goal for an intervention is identified (e.g. avoiding losses and damages to residential homes) and additional co-benefits are primarily

considered as a way to increase attractiveness to funders by inflating benefit-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 for DRR and sustainable development for communities is already more established and the recent methodological advancements in appraisal tools for multiple resilience dividends in the developed world (Michel-Kerjan et al. 2013, RAND, 2018, Fung et al, 2020).

6. Conclusions

Disasters from climate related hazards have caused significant losses and damages globally over the last decades and are expected to raise further without additional action due to an increase in exposed assets and changing weather patterns and sea level rise caused by climate change. While higher investments in pre-event disaster resilience to reduce disaster risk worldwide is demanded by global key agreements, the largest share of investments currently goes into post-event emergency response and recovery. The concept of multiple resilience dividends aims to increase investments in pre-event disaster resilience by focusing on additional economic, social and ecological co-benefits that materialize independent from the occurrence of a disaster. This paper extends and analyses the theoretical concepts, methods and empirical base for applying this concept to DRR interventions on the community scale. The paper improves the understanding on the existing challenges and knowledge gaps that have so far prevented the high-level multiple resilience dividend concept being widely applied on the community scale.

Using a mixed-method approach with empirical data on community level DRR interventions and in-depth case study analysis two mutually influencing key challenges have been identified. A lack of decision-making frameworks that can include and monitor multiple resilience dividends through the entire decision-making process for DRR interventions, resulting in multiple resilience dividends not being considered in the planning stage due to a lack of quantitative information. And a lack of suitable monitoring and evaluation routines that allow capturing the required quantitative evidence after a DRR intervention was implemented. High levels of scepticism towards DRR interventions with multiple resilience dividends by local decision makers fuelled by a pressure to effectively reduce losses and damages, lacking evidence when and if resilience dividends materialize and resilience dividends that do not fit the social, ecological and economic needs of their communities, the paper highlights that examples of successfully implemented dedicated community DRR interventions with multiple resilience dividends are needed but still scarce.
The paper therefore proposes an integrated decision-making framework that allows to systematically include, appraise, implement and evaluate individual resilience dividends at each stage of the decision-making process. This allows for a tailored approach in which only those resilience dividends are included in the planning process that are demanded by communities to support local buy-in, while at the same time systematically record and valuate resilience dividends once they materialized to be fed back to iteratively improve the evidence base on multiple resilience dividends in community DRR interventions.

7. References

Bouwer L.M. (2019) Observed and Projected Impacts from Extreme Weather Events: Implications for Loss and Damage. In: Mechler R., Bouwer L., Schinko T., Surminski S., Linnerooth-Bayer J. (eds) Loss and Damage from Climate Change. Climate Risk Management, Policy and Governance. Springer, Cham. https://doi.org/10.1007/978-3-319-72026-5_3

Brent RJ (1998) Cost–benefit analysis for developing countries. Edward Elgar, Cheltenha

Bubeck, P., Botzen, W. J. W., Suu, L. T. T., & Aerts, J. C. J. H. (2012). Do flood risk perceptions provide useful insights for flood risk management? Findings from central Vietnam. *Journal of Flood Risk Management*, 5(4), 295-302.

Bubeck, P., Hudson, P., Pham, M., Hagedoorn, L., Le, T., Brander, L., Tran, T., Haer, T. Wolf, S., Ickert, J., Dillenardt, L. & Lasage, R. (2019). Strong roots, strong women: Women and ecosystem-based adaptation to flood risk in Central Vietnam.

Davis, I., & Alexander, D. (2015). *Recovery from disaster*. Routledge.

EA (2018) Delivering benefits through evidence – Accounting for adaptive capacity in FCERM options appraisal, Environment Agency, Bristol, UK URL: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/690257/Accounting_for_adaptive_capacity_in_FCERM_options_appraisal_-_user_guide.pdf

Formetta, G., & Feyen, L. (2019). Empirical evidence of declining global vulnerability to climate-related hazards. *Global Environmental Change*, 57, 101920.

Fung, J. F., & Helgeson, J. F. (2017). *Defining the resilience dividend: Accounting for co-benefits of resilience planning* (No. Technical Note (NIST TN)-1959).

Fung, J. F., Helgeson, J. F., Webb, D. H., O'Fallon, C. M., & Cutler, H. (2020). Does resilience yield dividends? Co-benefits of investing in increased resilience in Cedar Rapids. *Economic Systems Research*, 1-27.

GCA (2019). Adapt Now: A global call for leadership on climate resilience. Global Commission on Adaptation, Rotterdam, The Netherlands

GCA (2020). A Global Call for Leadership on Climate Resilience. *Global Center on Adaptation and World Resources Institute*.

Herrero, S.T., Ürge-Vorsat, D. and Petrichenko, K., 2013. Fuel poverty alleviation as a co- benefit of climate investments: evidence from Hungary. In *European council for an energy efficient economy summer study*. 1605–1616.

IFRC (2017) Helping Tugu Utara Village deal with waste, Technical solutions, International Federation of Red Cross and Red Cresent Societies. URL: https://preparecenter.org/wp-content/sites/default/files/ifrc_solution_tugu_utara_waste_management_en_0.pdf

IOM (2020).Disaster Risk Reduction and Resilience. Emergency Manual. International Organisation for Migration – UN Migration. Grand-Saconnex, Switzerland

Khew, Y. T. J., Jarzebski, M. P., Dyah, F., San Carlos, R., Gu, J., Esteban, M., Aranguiz, R. & Akiyama, T. (2015). Assessment of social perception on the contribution of hard-infrastructure for tsunami

mitigation to coastal community resilience after the 2010 tsunami: Greater Concepcion area, Chile. *International Journal of Disaster Risk Reduction*, *13*, 324-333.

Keating, A., & Hanger-Kopp, S. (2020). Practitioner perspectives of disaster resilience in international development. *International Journal of Disaster Risk Reduction*, *42*, 101355.

Koetsier, I. (2017). Natural disasters and (future) government debt. In *Public or Private Goods?*. Edward Elgar Publishing.

Kron, W., & Müller, O. (2019) Efficiency of flood protection measures: selected examples*. Water Policy, 21(3), 449–467.* doi:10.2166/wp.2019.023

Laurien, F., & Keating, A. (2019). Evidence from Measuring Community Flood Resilience in Asia. *Asian Development Bank Economics Working Paper Series*, (595).

McVittie, A., Cole, L., Wreford, A., Sgobbi, A., & Yordi, B. (2018). Ecosystem-based solutions for disaster risk reduction: Lessons from European applications of ecosystem-based adaptation measures. *International Journal of Disaster Risk Reduction*, *32*, 42-54.

Mechler, R. (2016). Reviewing estimates of the economic efficiency of disaster risk management: opportunities and limitations of using risk-based cost–benefit analysis. *Natural Hazards*, *81*(3), 2121-2147.

Mechler, R., & Hochrainer-Stigler, S. (2019). Generating Multiple Resilience Dividends from Managing Unnatural Disasters in Asia: Opportunities for Measurement and Policy. *Asian Development Bank Economics Working Paper Series*, (601)

Michel-Kerjan, E., Hochrainer-Stigler, S., Kunreuther, H., Linnerooth-Bayer, J., Mechler, R., Muir-Wood, R., Ranger, N., Vaziri, P. & Young, M. (2013). Catastrophe risk models for evaluating disaster risk reduction investments in developing countries. *Risk Analysis*, 33(6), 984-999.

Onuma, A., & Tsuge, T. (2018). Comparing green infrastructure as ecosystem-based disaster risk reduction with gray infrastructure in terms of costs and benefits under uncertainty: A theoretical approach. *International Journal of Disaster Risk Reduction*, *32*, 22-28.

Raymond, C. M., Frantzeskaki, N., Kabisch, N., Berry, P., Breil, M., Nita, M. R., Geneletti, D. & Calfapietra, C. (2017). A framework for assessing and implementing the co-benefits of nature-based solutions in urban areas. *Environmental Science & Policy*, 77, 15-24.

Reyers, B., Nel, J. L., O'Farrell, P. J., Sitas, N., & Nel, D. C. (2015). Navigating complexity through knowledge coproduction: Mainstreaming ecosystem services into disaster risk reduction. *Proceedings of the National Academy of Sciences*, *112*(24), 7362-7368.

Rodin, J. (2014). *The resilience dividend: being strong in a world where things go wrong*. Public Affairs.

Scrieciu, S.Ş. et al., 2014. Advancing methodological thinking and practice for development-compatible climate policy planning. *Mitigation and Adaptation Strategies for Global Change*, 19(3), 261–288.

Shabnam, N. (2014). Natural disasters and economic growth: A review. *International Journal of Disaster Risk Science*, *5*(2), 157-163.

Shreve CM, Kelman I (2014) Does mitigation save? Reviewing cost–benefit analyses of disaster risk reduction. *International Journal of Disaster Risk Reduction*. 10(Part A):213–235

Surminski, S. and Tanner, T (eds.) (2016) Realising the 'Triple Dividend of Resilience' - A new business case for disaster risk management, Springer.

Tanner, T. et al., 2015. *The Triple Dividend of Resilience: Realising development goals through the multiple benefits of disaster risk management*, Overseas Development Institute, The World Bank.

Tomczyk, A. M. , White, P. C. L. , & Ewertowski, M. W. (2016). Effects of extreme natural events on the provision of ecosystem services in a mountain environment: The importance of trail design in delivering system resilience and ecosystem service co-benefits. *Journal of Environmental Management* , *166* , 156–167.

United Nations-UN (2015). Sendai framework for disaster risk reduction 2015–2030, A/CONF.224/CRP.1, 18 March 2015.

Van Tuyen, T., Armitage, D., & Marschke, M. (2010). Livelihoods and co-management in the Tam Giang lagoon, Vietnam. *Ocean & Coastal Management*, 53(7), 327-335.

Vorhies, F., & Wilkinson, E. (2016). Co-benefits of Disaster Risk Management: The Third Dividend of Resilience. In *Realising the'Triple Dividend of Resilience'* (pp. 55-72). Springer, Cham.

Wardekker, J.A. et al., 2016. Screening regional management options for their impact on climate resilience: an approach and case study in the Venen-Vechtstreek wetlands in the Netherlands. *SpringerPlus*, 5(1), 1–17.

Wolf, S., Pham, M., Matthews, N., & Bubeck, P. (2020). Understanding the implementation gap: policy-makers' perceptions of ecosystem-based adaptation in Central Vietnam. *Climate and Development*, 1-14.

Wright, K. (2016). Resilient communities? Experiences of risk and resilience in a time of austerity. *International journal of disaster risk reduction*, *18*, 154-161

Acknowledgements

We wish to thank Brandon Carter for his time and effort in reviewing this paper. We would also like to thank Paul Hudson and Paul Mackie for providing additional information for the case studies in Vietnam and the UK. This work was supported by the Z Zurich Foundation, Switzerland; the Grantham Foundation for the Protection of the Environment and the ESRC via the Centre for Climate Change Economics and Policy under Grant number: ES/R009708/1.

Appendix

A1 DRR interventions questionnaire

1. Name of 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)

A2 Case studies – Guiding questions

1. In what context is the resilience project implemented in? (Country/Region, developing vs. developed world, urban vs. rural, number of beneficiaries/number of affected people living in the area)?
2. What are the main hazards the community/area is facing (different types of flooding, landslide, drought, etc.)?
3. What are the pre-conditions? (skills, capacities, framing, project context, theory of change etc.)
4. What role do institutions play? (standards set by national and local governments, reporting and evaluation criteria etc.)
5. What measures/ type of measure (hard resilience, nature-based, soft resilience (capacity building, education programs etc.) are implemented/considered?

6. What phase is the project currently in (planning, implementation, completed)?
7. Which tools and methods are used?
8. What evidence on additional dividends is reported and was initially considered (2nd and 3rd dividends)?
9. What are the challenges at different stages of the decision making process (tools, business case not convincing for decision makers, institutional barriers etc.)
10. Any particularities? (aspects that are unique about this case or can be pinned down to a specific circumstance)
11. Is there a focus on multi-risk/compound risk? (beyond flooding for example)

A3 Additional Material (on request)

A3.1 Dataset DRR interventions questionnaire
A3.2 Dataset case studies