Chapter 1:
The Triple Dividend of Resilience – a new narrative for disaster risk management and development?

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Abstract

To secure development gains and help eradicate poverty in the long run, it is critical to strengthen *ex-ante* disaster risk management (DRM) measures that build resilience at the household, firm and macro level. Decision-makers however often view DRM investments as a gamble that pays off only in the event of a disaster. This is despite increasing evidence that building resilience yields significant and tangible benefits, even if a disaster does not happen for many years.

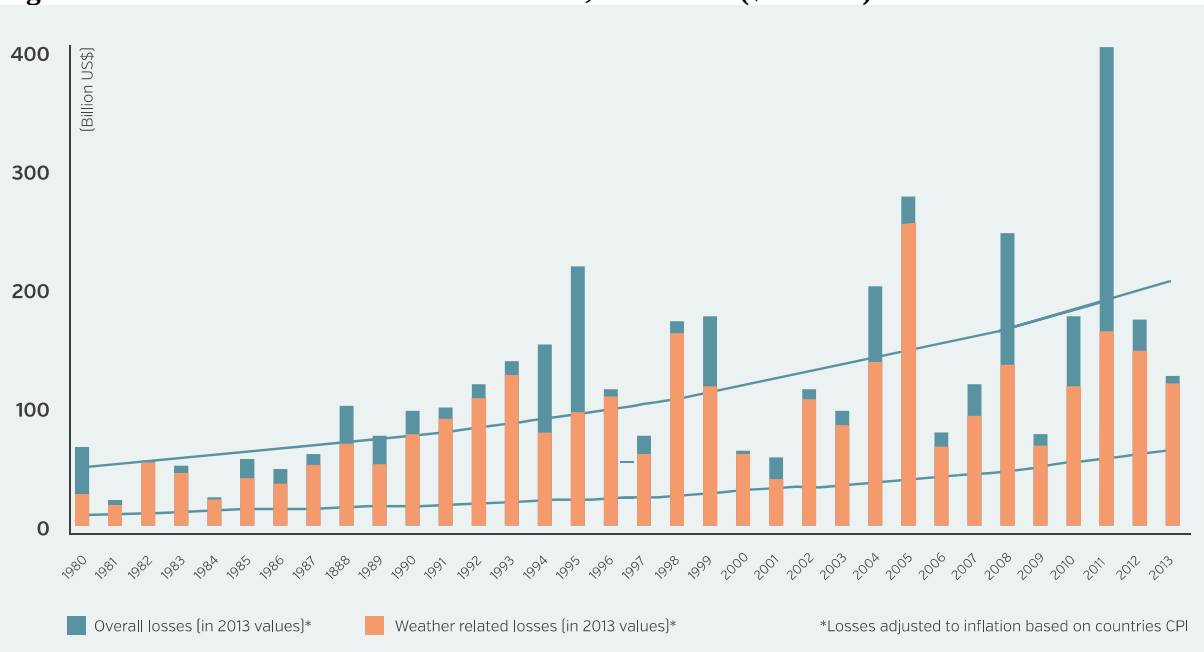
This chapter outlines the triple dividend of resilience as a new analytical method to enhance the business case for investments in building resilience. The three types of benefits are outlined that include: 1) avoiding losses when disasters strike; 2) unlocking development potential by stimulating economic activity thanks to reduced disaster-related investment risks; and 3) social, environmental and economic co-benefits associated with investments. The second and third dividends in particular are typically overlooked in appraisals around investment decisions, and can accrue even in the absence of disaster events. Presenting evidence of additional dividends to policy-makers and investors can provide a stronger case for investment in DRM, helping to reconcile short- and long-term objectives. This chapter provides the conceptual basis for the more detailed assessments of the resilience streams and implications for decision-makers provided in the following chapters.

1.1. The case for investing in resilience

1.1.1 Disasters, poverty and development

There is growing awareness that disaster and climate risk threatens future growth and development. The total number of disaster events has been increasing since the 1980s, with this trend set to continue, driven by climate change, population growth, urbanisation, more people living in coastal areas and floodplains and the degradation or loss of natural ecosystems (Field et al. 2012; UNISDR 2015a). Economic losses from "natural" disasters are now reaching $150–200 billion each year, up from $50 billion in the 1980s (see Figure 1.1), while projected future disaster losses in the built environment alone are estimated at $314 billion per year (UNISDR 2015a).

Figure 1.1: Disaster and weather-related losses, 1980–2013 ($ billions)



Source: Munich Re (2014), in GFDRR (2015).

The increasing frequency of devastating disasters is a major obstacle to the reduction of poverty and promotion of shared prosperity. While progress in human development has been remarkable in the past two decades, with global levels of extreme poverty likely to fall to under 10% of the global population in 2015 (World Bank 2015), gains have not been evenly distributed between or within countries (World Bank 2013). Without concerted action, by 2030 there could be up to 325 million extremely poor people living in the 49 countries most exposed to natural hazards and climate extremes, the majority in South Asia and Sub-Saharan Africa (Shepherd et al. 2013). Urban growth will be a particularly strong driver, with the global urban population increasing by 1.4 million each week, roughly the size of Stockholm (Global Commission on the Economy and Climate 2015). Most of this expansion is occurring in low- and middle-income countries, where the growth of informal settlements amplifies disaster risk as low-income families are forced to occupy hazard-prone areas with low land values, deficient infrastructure, a lack of social protection and high levels of environmental degradation (UNISDR 2015a).

1.1.2 Incentivising *ex-ante* disaster risk management

A range of reports have emphasised the need to incentivise and enable greater *ex-ante* disaster risk management (DRM) (Field et al. 2012; UNISDR 2015a; World Bank 2013). A range of international policy frameworks echo this message, including the Sendai Framework for Disaster Risk Reduction, the Financing for Development Framework, the Sustainable Development Goals and the climate change agreements, all of which these highlight the importance of investing in resilience. However, it still is not happening at the rate needed to curb rising disaster losses. Although some countries, cities

and communities have made progress, funding is still heavily biased towards *ex-post* measures. Meanwhile, the importance of such *ex-ante* prevention is not yet reflected much in the policy and practice of governments, aid agencies, communities or businesses (Kellet and Caravani 2012).

There are many reasons for this underinvestment in disaster resilience. These include lack of resources in poor countries, limited understanding of risks and impacts, greater political buy-in for more visible post-disaster support initiatives and the ready availability of international post-disaster assistance (Keefer 2009; Wilkinson 2012; World Bank 2013). In particular, DRM suffers from a lack of salience with citizens, as the benefits are hard to perceive (Wilkinson 2012). Crucially, policy-makers tend to underinvest or not invest at all in projects to manage risk because the costs of such investments are visible and immediate, whereas their direct benefits and the distribution of these are unclear, uncertain and distant. Existing methods of appraising investment decisions often fail to incentivise DRM because they undervalue the resulting benefit streams.

There are also reasons why individuals choose to stay and invest in risky areas (Chapter 2). Increased exposure to natural hazards may be seen as an unavoidable side-effect of investments to create additional employment and growth from international trade in areas characterised by low transportation costs but exposed to flood risks (Gallup et al. 1998). In China, for instance, total factor productivity (TFP) is 85% higher in coastal regions than inland, and TFP growth is not significantly different despite higher investment in inland regions, suggesting lower transport costs offer a permanent productivity advantage in coastal regions (Fleisher and Chen 1997). Similarly, poor people living in flood-prone areas in Mumbai are well aware of the risks and make deliberate decisions to live where they do to benefit from higher wages and better schools and medical care (Patankar 2015).

To counter these problems, this chapter examines a shift in the narrative away from a singular focus on losses as a driver for action towards the recognition and appraisal of a broader set of dividends from investing in DRM. We argue that DRM investment should be considered within decision-making as something that is good for wealth, wellbeing, profit, growth and sustainable development, in addition to preventing human and economic losses should a disaster strike. Through the use of the triple dividend concept, we examine evidence of the wider benefits of investing in resilience measures with the intention of improving awareness and stimulating the development of appraisal tools that can incorporate these factors and enhance future investments in DRM.

1.2. The triple dividend: A comprehensive business case for resilience

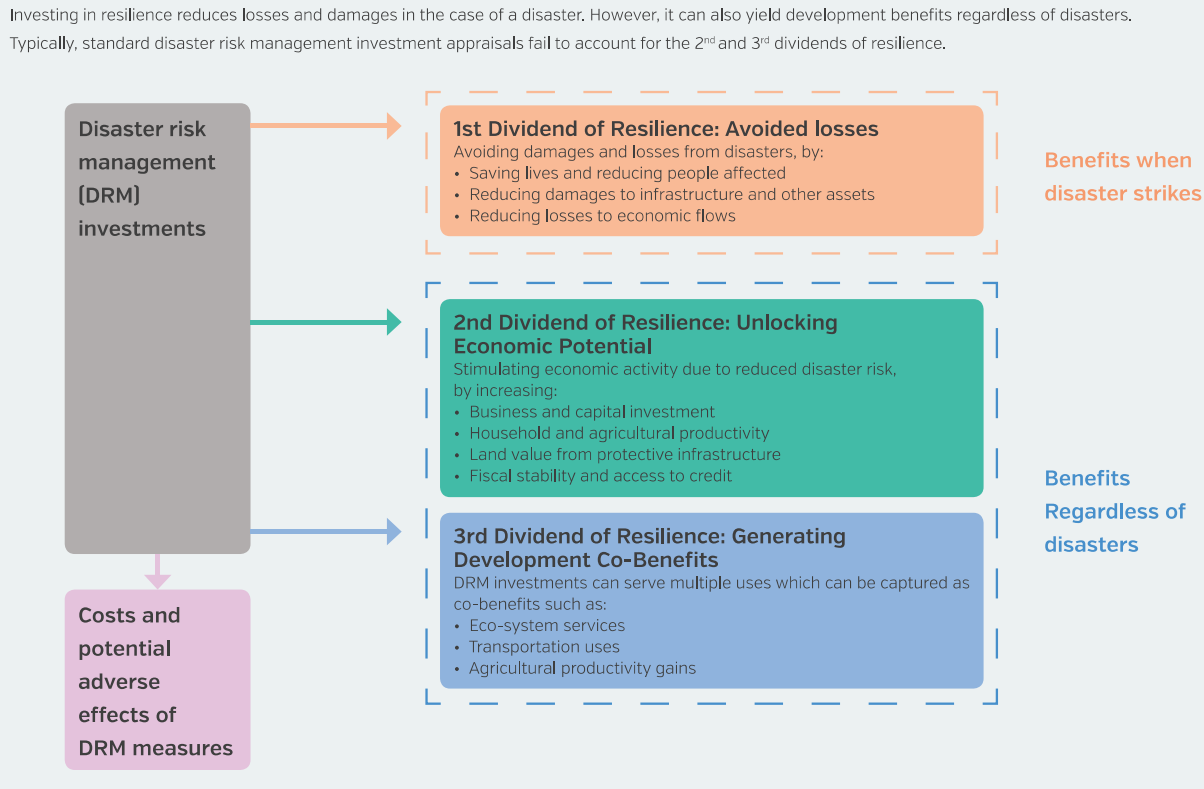
Investing in DRM yields a wide range of benefits in the short and long term: if a disaster does strike, then prior planning and investments help reduce human and economic losses. This is the basic rationale and common narrative for DRM, associated with saving lives, reducing losses and supporting both individuals and communities to quickly and effectively bounce back from disasters. However, there is a range of resilience dividends (Rodin 2014; WRI 2008) associated with DRM investments. The risk of disasters creates background risk, which constrains investment in capital productivity and development for fear of disaster events eroding returns. DRM enables forward-looking planning, long-term capital investments and entrepreneurship. These are all crucial elements for economic growth and shared prosperity. Investments in DRM and resilience also generate wider social, economic and environmental co-benefits irrespective of disasters. These could include multiplier effects on employment or trade or strengthening water and sewage systems. Importantly, many investments can be specifically designed to have a dual use, such as roads that act as embankments or tunnels that can also serve as water retention and drainage systems. As such, determining whether an investment is a DRM measure with development co-benefits or a development measure with DRM co-benefits is often a matter of perspective.

This chapter argues that a more complete understanding of this wide range of benefits—or dividends—of DRM investments is critical for strengthening the business case for building resilience. In particular, we propose three concrete dividends from *ex-ante* DRM measures:

1. **The first dividend ("avoided losses").** Investing in DRM strategies takes the form of reduced losses and damages in the event of a disaster. These losses and damages can be both direct and indirect, leading to both immediate and long-term effects. Most notably, the first dividend includes saved lives, along with prevented or reduced damage to infrastructure and assets. This corresponds to the conventional *ex-post*, loss-centric view, and is likely to underestimate the benefits of DRM measures.
2. **The second dividend ("unlocking economic potential").** Even the mere possibility of a future disaster has real impacts on present-day economic growth, particularly in regions or localities where disaster risks are perceived to be high. DRM measures help manage this ever-present background risk of potential future disasters. This helps unlock economic development potential by enabling forward-looking planning and investment. Increased resilience can catalyse innovation, entrepreneurship and investment in productive assets—even if disasters do not occur for a long time.
3. **The third dividend ("generating development co-benefits").** DRM investments are typically associated with economic, social and environmental uses, or "co-benefits". Co-benefits can play an important role in motivating DRM measures and determining their design (e.g. shelters doubling as community spaces or flood protection infrastructure doubling as roads). While the nature of co-benefits varies significantly, they all materialise even in the absence of a disaster.

Figure 1.2 summarises the three dividends of resilience. This chapter is a first step in bringing together evidence that helps characterise the dividends resulting from DRM investments. These are used to build the case for an incentive structure for DRM that goes beyond avoided losses.

Figure 1.2: The triple dividend of resilience—strengthening the case for investing in DRM



The following sections illustrate each of the three dividends of resilience in turn. For example, the World Bank and Mexico's Ministry of Finance elaborated a joint study to determine the impact of investment in flood defence in terms of reducing flood damage in the state of Tabasco between 2007 and 2010. The first dividend was revealed by the cost–benefit ratio of these benefits, which was 4:1, contributing to avoided damages and losses when floods occurred in 2010 equivalent to $3 billion, or

7% of the gross domestic product (GDP) of Tabasco (World Bank 2014a). This high ratio supports the business case of investing in DRM, but it could be further strengthened if it captured the full range of dividends associated with these investments, such as new flood defences helping maintain existing and stimulate new investments. For instance, continued investment by companies in the Tabasco region that were otherwise leaving further strengthens the case for avoided losses. Additionally, the second dividend is evident from reduced background risk encouraging private investment in housing in previously flood-prone areas and public investment in improved drainage and electricity networks in areas where floods had previously deterred such investment (ibid.).

In addition, the capital of Tabasco, Villahermosa, has seen improvements in the urban environment as a result of federal government investment in flood defence. Major DRM investments have stimulated local actors to take greater care of the environment while small-scale projects with environmental benefits have been initiated, including tree-planting on riverbanks to prevent landslides, which could potentially reveal environmental co-benefits as mentioned under the third dividend. People are beginning to dispose of litter more responsibly, throwing less on the streets or into drains, helping avoid blockages during the rainy season (see Chapter 3).

This example also demonstrates the need to examine the possible negative consequences, which could be considered negative co-benefits associated with a comprehensive assessment. For example, a report by the Colegio de la Frontera Sur suggests there are a number of unintended negative externalities associated with the flood defence project in Tabasco (Díaz-Perera 2013; see Chapter 3). Channelling water away from the capital Villahermosa has led to increased flooding elsewhere in the state, mainly in rural areas. There have also been negative environmental impacts as a result of these large construction projects. These negative impacts also need to be considered when weighing up the full range of costs and benefits associated with a particular DRM investment. The triple dividend framework presented here helps inform more comprehensive cost–benefit calculations.

1.3. The first dividend of resilience: Saving lives and avoiding losses

Saving lives and avoiding losses (the first dividend of resilience)

DRM measures can avoid or reduce losses and damages (both immediate and long run) in the event of a disaster. They include:

- Saving lives and reducing numbers of people affected
- Reducing direct damages to infrastructure and other assets
- Reducing economic and non-monetary losses (direct and indirect).

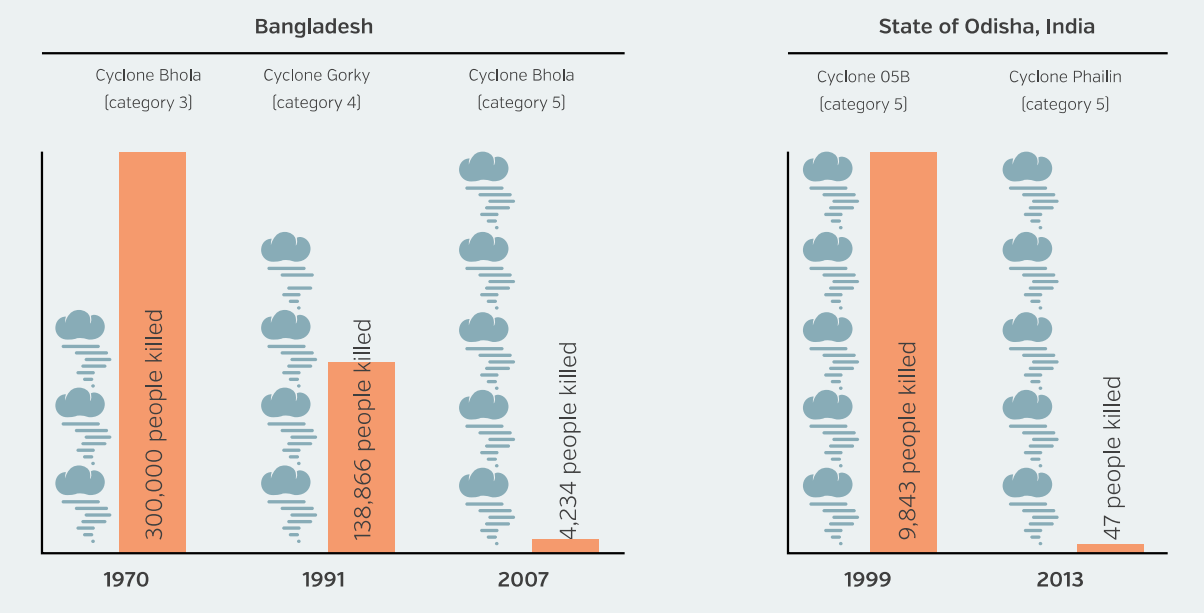
The triple dividend of resilience approach outlined earlier is motivated by the observation that fully acknowledging the benefits of resilience will strengthen the business case for DRM investments. However, while other benefits of DRM can play substantial roles, the primary objective of DRM remains clear: to save lives, while also reducing loss and damage to people and their assets. In recognition of the importance of this objective, this section briefly highlights the evidence for effective risk management that limits human and economic disaster losses.

1.3.1 Saving lives and reducing numbers affected

Effective DRM policies and actions are often measured by their ability to save lives and reduce the number of people affected by disasters. To this effect, progress in saving lives has been marked. As reported in the 2015 Global Assessment Report (GAR), “improvements in disaster management have led to dramatic reductions in mortality in some countries” (UNISDR 2015a). In Bangladesh, deaths from cyclones have been reduced considerably, owing to a combination of strengthened coastal defences, cyclone shelters and early warning systems (EWS).

While comparisons across countries and events are difficult because of contextual differences, it is possible to infer levels of preparedness and effectiveness of DRM measures through observing the impacts of similar hazards (see Figure 1.3). In 2010, the existence and enforcement of building codes helped limit earthquake damage in Chile, with less than 1,000 people killed, despite a magnitude 500 times greater than the Haiti quake of the same year that killed over 230,000 (Lovett 2010). More recently, increased investment in infrastructure and disaster preparedness paid off in the latest earthquake and tsunami in September 2015 in Chile, which resulted in relatively low casualties, despite a 8.2 magnitude (UNISDR 2015b). Volcano-related mortality has also decreased significantly as a result of volcano monitoring, assessments and EWS; and, although not all volcanoes are monitored, it is estimated that such measures have saved about 50,000 lives over the past century (Auker et al. 2013).

Figure 1.3: Reduced cyclone mortality in Bangladesh and Odisha, India



Source: Munich Re (2014), in GFDRR (2015).

DRM interventions can also save lives through acknowledging different people's needs, vulnerabilities and capacities. Integrating indigenous knowledge into DRM initiatives has been shown to help avoid loss of life. For example, oral history on ocean and buffalo behaviour meant the inhabitants of Simeulue Island in Indonesia had early warning before the Indian Ocean tsunami in 2004 and were able to retreat to the hills. As a result, only seven out of 78,000 people died in the tsunami, despite the island being located just 40 km from the epicentre of the earthquake (Lovell and le Masson 2014).

1.3.2 Reducing damages and losses

There is a strong body of evidence for the effectiveness of DRM measures gathered from projects around the world. The 2015 GAR concludes that "annual global investment of US$6 billion in appropriate disaster risk management strategies would generate total benefits in terms of risk reduction of US$360 billion. This is equivalent to an annual reduction of new and additional average annual loss by more than 20 percent" (UNISDR 2015a). Mechler and Bouwer (2014) make the case that, despite the increase in risk exposure, various DRM strategies have decreased vulnerabilities throughout the world.

Infrastructure, EWS and planning are three areas where DRM investments have been critical in reducing losses from disasters. Infrastructure losses have particularly profound consequences for development progress. Between 2015 and 2030, approximately $90 trillion is expected to be invested globally in infrastructure to meet the world's urban, land use and energy needs (Global Commission

on the Economy and Climate 2014). This is particularly pertinent in Asia and Africa, where 90% of urban growth is expected to take place between now and 2050, which will result in accompanying infrastructure needs (UNDESA 2014). It is crucial that these huge financial investments are disaster-resilient, as this will protect lives and secure development progress.

Infrastructure losses often go well beyond physical damage. Business losses can be the consequence of "ripple effects" as the impacts of shocks propagate both upstream (backward) from clients to suppliers and downstream (forward) from suppliers to clients. The 2011 Thai floods' impact on global supply chains forced Toyota to slow down production in factories in Indonesia, Japan, Malaysia, Pakistan, the Philippines, South Africa, Vietnam and North America. Locating industrial parks in protected areas less prone to flooding would have improved disaster resilience and reduced losses (Scor SE 2013). Similarly, the Tohoku-Pacific earthquake in Japan in March 2011 reduced domestic industrial production and the exports of goods used as inputs in the auto industry, leading to a reported cut in production at Toyota's Indian subsidiary by up to 70% between 25 April and 4 June (The Economic Times 2011).

EWS are frequently cited for their role in reducing economic losses of disasters by triggering other important prevention actions, as there is more lead time to protect assets. While issues of attribution and lack of widespread cost benefit calculations complicate the evidence base (Rogers and Tsirkunov 2011), Table 1 suggests significant loss and damage reduction is possible owing to an early warning of different lead times on a number of different movable assets (Subbiah et al. 2008).

Table 1.1: Damage reduction owing to early warning of different lead times

Item	Lead time	Damage reduction (%)	Actions taken to reduce damages
Household items	24 hrs	20	Removal of some household items
	48 hrs	80	Removal of additional possessions
	Up to 7 days	90	Removal of all possible possessions including stored crops
Livestock	24 hrs	10	Poultry moved to safety
	48 hrs	40	Poultry, farm animals moved to safety
	Up to 7 days	45	Poultry, farm animals, forages, straw moved to safety
Agriculture	24 hrs	10	Agricultural implements and equipment removed
	48 hrs	30	Nurseries, seed beds saved, 50% of crop harvested, agricultural implements and equipment removed
	Up to 7 days	70	Nurseries, seed beds saved, fruit trees harvested, 100% of crop harvested, agricultural implements and equipment removed
Fisheries	24 hrs	30	Some fish, shrimps, prawns harvested
	48 hrs	40	Some fish, shrimps, prawns harvested, nets erected
	Up to 7 days	70	All fish, shrimps, prawns harvested, nets erected, equipment removed
Open sea fishing	24 hrs	10	Fishing net, boat damage avoided
	48 hrs	15	Fishing nets removed, boat damage avoided
School or office	24 hrs	5	Money, some office equipment saved
	48 hrs	10	Money, most office equipment saved
	Up to 7 days	15	Money, all office equipment, including furniture protected

Source: Subbiah et al. (2008).

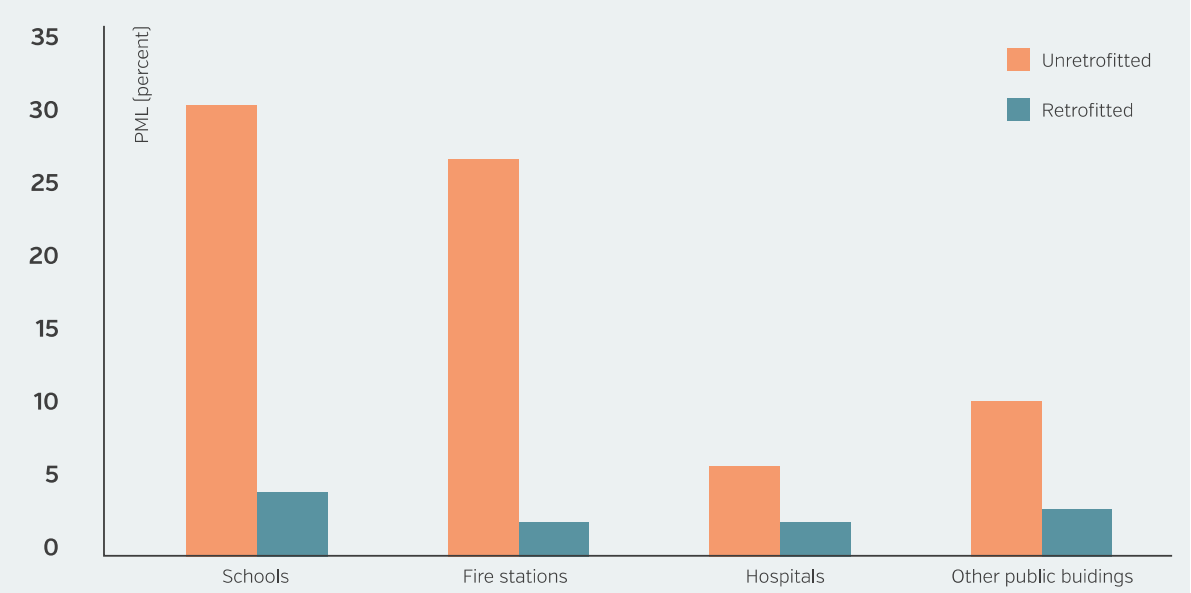
Establishing and enforcing risk-informed, locally appropriate standards and codes for new buildings and other infrastructure reduces the risk of damage to structures in the event of a disaster. Existing infrastructure can also be retrofitted to adhere to building standards. For example, Cyclone Ian in Tonga in 2014 had significantly less impact on houses constructed to cyclone standards in the early 1980s than it did on many newer houses that were not built in compliance with the standard. These were completely destroyed or severely damaged (GFDRR 2014). Similarly, homes built with typhoon-resistant features as part of the Storm Resistant Housing for a Resilient Da Nang City project in Vietnam showed no damage when Typhoon Nari hit in October 2013 (Tran 2013).

A World Bank study of earthquake vulnerability in Colombia (Ghesquiere et al. 2006) assessed a range of measures that were:

- Structural (retrofitting and reinforcement of public buildings, such as schools, hospitals, fire stations and administrative buildings)
- Non-structural (the resettlement of vulnerable populations in high-risk areas)
- Functional (protection of people and assets, so they remain functional during and immediately after an emergency)

A probabilistic cost–benefit analysis helped demonstrate to decision-makers the significant reductions in probable maximum loss (PML) of a one-in-1,000-year earthquake event, before and after structural investments were made (shown below in Figure 1.4). The average annual returns on mitigation investments for schools, hospitals and fire stations were estimated to be as high as 19% for structural investments and 32% for structural and functional investments. In addition to the direct costs of structural and functional assets, there may be significant indirect losses. One example of this would be the way disruption to education can constrain future career options and prosperity later in life.

Figure 1.4: PML of a 1,000 year earthquake event, before and after structural investments



Source: Ghesquiere et al. (2006).

The examples above suggest the avoidance of loss usually provides a critically important stream of benefits for DRM investments. Widening avoided loss calculations beyond immediate asset losses to include the impact of disasters on the wider economy and society can help strengthen the case for investing in DRM. Nevertheless, several factors limit the potential incentivising role. First, these wider benefits are hard to identify, calculate and attribute. This is because they rely on counter-factual reasoning, in that a DRM investment will reduce the probability of a disaster happening. It is difficult to measure the impact of something not happening. Second, same parties facing the costs of

investment may not enjoy the benefits, although this may not be a problem for governments concerned with wider economic and social goods. However, the most critical point to consider here, from the perspective of this chapter, is that using loss-based approaches to justify investment is reliant on the occurrence of a disaster event in the future, which is a major flaw. By identifying the dividends of resilience that are delivered even in the absence of disaster events, and incorporating them in decision-making, the case for investing in resilience can be greatly improved.

1.4. The second dividend of resilience: Unlocking economic potential

Unlocking economic potential (the second dividend of resilience)

DRM measures that reduce the background risk resulting from potential future disasters can have immediate and significant development benefits. Increased resilience enables forward-looking planning, long-term capital investments and entrepreneurship, even if disasters do not occur for a long time. These benefits include:

- Economic gains from positive risk=taking (e.g. entrepreneurship and innovation)
- Investments in productive assets (e.g. in small-scale agriculture)
- Extending planning horizons (e.g. for building up savings)
- Increase in land values after DRM investment

In disaster-prone places, risks of extreme weather events and disasters create an ever-present background risk. As a consequence, risk-averse households and firms avoid long-term investments in productive assets, entrepreneurship is restricted and planning horizons are shortened, meaning development opportunities are lost. By reducing this background risk, or by helping households and firms manage it effectively, DRM measures can have immediate and significant economic benefits.

This section presents evidence that investments in *ex-ante* DRM can unlock economic opportunities for households, government and the private sector and, more broadly, at the macroeconomic level. For example, the evidence from poor rural households dependent on agricultural income suggests strengthening *ex-ante* DRM enables households to increase savings and investment in productive assets, thereby improving their productivity and livelihoods. Further examples show how DRM measures can increase land values, as well as improve credit access, fiscal management and public sector coordination. Overall, increased resilience can be argued to be a catalyst for positive risk-taking such as capital investments, entrepreneurship and innovation, along with forward-looking planning.

1.4.1 Increased business and capital investment

Without effective instruments for managing disaster risks and the adverse consequences of disasters, investment decisions are likely to be excessively risk-averse (Elbers et al. 2007; Gollier and Pratt 1996). As a result, businesses refrain from engaging in entrepreneurial activities and innovation or making long-term investments in productive assets.

One of the most immediate benefits that investing in DRM has to offer the private sector relates to investment risk-taking. Taking positive risks, engaging in entrepreneurial activities and investing in productive assets and innovation are the drivers of job creation, rising incomes, greater productivity and overall economic growth. However, the perceived risk of future disasters can lead to greater risk aversion, which dampens entrepreneurial activity (Chapter 5). Investing in DRM can help reduce this background risk and provide better information on residual risk, which in turn helps promote the entrepreneurship and investment needed for economic growth and job creation. While risk-taking can increase welfare, there may be a trade-off between exposure to natural hazards and productivity or economic growth in high disaster risk situations. Public and private investment in improved risk management can mitigate this trade-off, reducing the background risk that prevents people from investing, therefore improving productivity and accelerating growth (Hallegatte 2014).

Similarly, disaster insurance can encourage the kind of "positive risk-taking" that is arguably fundamental to the development process, making investments more secure and therefore fostering business innovation and growth (Chapter 2). However, disaster insurance may also lead to moral hazards if it is not designed with the correct control measures in place. This points to a potential counter effect of using insurance, where it can create a false sense of security, increase vulnerability to exceptional events or encourage inappropriate development in high-risk areas (Surminski 2014).

Investing in DRM can generate benefits that extend across sectors to the macroeconomic level. A region- or country-wide boost to productive investments can boost the overall development of a country. Protecting coastal regions, towns, business districts or ports from flood can foster economic activity, long-term planning and capital investments. This is because, where well designed and maintained, large DRM infrastructure investments (such as dikes) can protect not only large firms themselves but also their workers and suppliers, along with their social and logistic infrastructure. If DRM investments enable firms and their stakeholders to make long-term capital investments, engage in trade and thus promote business development, the entire area benefits collectively (Hallegatte 2014; World Bank 2013).

Firms may also benefit from improvements to their image and credit ratings, through increased stability (Chapter 5). There is some evidence of businesses taking this "good citizen" image seriously; for example, in a set of six case studies of companies describing their activities related to managing the physical impacts of extreme weather and climate change, most saw avoidance of disaster impacts (both now and in the future) as only part of the logic for investing in resilience (Crawford and Seidel 2013). Companies such as American Water, The Hartford, National Grid and Rio Tinto all emphasised that fulfilling, or staying ahead of, regulatory and disclosure requirements and new government policy were key business drivers for investing in resilience. A survey of European companies also revealed that investing in resilience could help develop market opportunities, with 43% of the companies surveyed anticipating increased demand for existing products/services (CDP 2015).

1.4.2 Household and agricultural productivity dividends

When levels of background risk are high, evidence suggests households lacking effective risk management tools will tend to spread their overall risk. Rather than specialising, households tend to engage in a wider range of lower-risk activities, thereby reducing returns to assets and investments (Chapter 2). For example, there is evidence that rural households avoid focusing solely on agriculture and instead diversify occupations within households as a risk management measure—with negative impacts on long-term welfare (Rentschler 2013). While such actions reduce the risk of severe losses, they obstruct growth and incentives to invest (Carter and Barrett 2006; Dercon 2005).

An illustration of this effect can be provided in an agricultural context in Zimbabwe. Here, farmers exposed to risk exhibit a mean capital stock that is half as large as for farmers who are not exposed. Of this reduction in capital, *ex-ante* risk accounts for two thirds of the difference; hence, most of the welfare impact of risk comes through reduced investments and risk-taking, not damage and loss when a disaster occurs (Elbers et al. 2007; Chapter 2). Extending these findings into other decision-making contexts and sectors could provide crucial evidence to enhance the incentives for *ex-ante* investments in DRM.

Household insurance and social safety net programmes have been observed to stimulate savings, investment in productive assets and increases in agricultural productivity in a number of different countries, with subsequent improvements in income levels. In Ethiopia, the R4 Rural Resilience Initiative (previously the Horn of Africa Risk Transfer for Adaptation programme) is providing risk management support, including weather-indexed insurance to small-scale and subsistence farmers. Premiums are largely paid through labour to support risk management activities. In the event that rainfall drops below a predetermined threshold during the growing season, insurance payments are automatically triggered.

An evaluation of the programme has found that insurance is enabling farmers to increase their savings, which can act as an important reserve in the case of contingencies. Moreover, insured farmers have been found to increase their investments in productive assets, in particular oxen, but also fertiliser, improved seeds and compost—thus improving their overall productivity (Greatrex et al. 2015; Madajewicz et al. 2013).

Evaluations of the Mexican government's Committee for Natural Disasters and Emergencies programme show how weather-indexed insurance not only helps compensate for drought losses but also directly increases the productivity of small-scale farmers. The insurance programme has enabled farmers to overcome credit constraints and mitigated previously chronic underinvestment in tools and fertiliser. As a result, farmers have been able to increase their agricultural productivity, with an average 6% increase in maize yields. Evidence also shows that insured farmers invest in riskier and higher-yielding cultivation methods, with higher overall planting-stage investments than uninsured peers, enabling them to reconcile entrepreneurial investment decisions with effective risk management (Dar et al. 2013; Emerick et al. 2015).

Overall, these evaluations demonstrate how effective risk management tools not only yield significant benefits in the aftermath of a disaster but also can yield significant benefits even if disasters do not strike for many years, such as through increases in productivity and income levels. By reducing background risk, DRM measures can directly influence economic decisions and behaviour, actively contributing to a long-term sustainable economic development process. If implemented at sufficient scale, DRM measures (such as weather-indexed insurance programmes) can have significant economic development benefits at the macro level, and even be cost-effective in the absence of disasters.

1.4.3 Land value dividends from protective infrastructure

Investment in dams, levees and other structures to protect assets from disaster impacts can unlock economic potential through increases in productive investment and consequent increases in the value of land. To some extent, the efficiency of infrastructure provision can be measured by the relationship between land value capitalisation and infrastructure costs. When the benefits of capitalised land values exceed the costs of installing infrastructure, infrastructure is generally undersupplied. This relationship can be seen in Table 2, which demonstrates land value gains and infrastructure costs in Recife, Brazil. In this case, there is clearly a need for more investment in road pavement and wastewater removal in order to meet economic demand, as the land value gains exceed the costs of infrastructure supply. This is in contrast with the water supply, which has an almost equal land value capitalisation to investment cost ratio of 1:1 (Peterson 2012).

Table 1.2: Land value gains and infrastructure costs in Recife, Brazil

	Increase in land value ($ per square meter) by distance to centre			
Service	**5–10 km**	**15–20 km**	**25–30 km**	**Ratio of gain in land value to investment cost**
Water supply	11.1	5.1	3.2	1.02
Road pavement	9.1	4.8	3.4	2.58
Wastewater removal	8.5	1.8	0.3	3.03

Source: Peterson (2012.

In a similar way, protective infrastructure can also generate dividends of resilience. Hard infrastructure for protection, along with soft DRM measures, such as monitoring and early warning, can protect assets from disaster impacts. These factors are likely to have a positive effect on land prices, which also shows an increased willingness for people to invest in these areas, given a reduced background risk. These increased land values can in turn help raise government revenue, helping finance the cost of *ex-ante* DRM measures. It is possible to learn from building development projects,

where one of the most common strategies for recovering infrastructure costs involves the sale of land with enhanced value. Here, it can be seen that the business case for protective infrastructure investments can be more accurately costed in this way, particularly where the public sector owns the land.

1.4.4 Fiscal stability and future credit risks

There are a number of economic and other benefits of DRM to be recognised and realised by those in charge of fiscal policy decisions. Approaches organised around the protection of the balance sheet using risk-financing instruments have seen growing emphasis in disaster-prone countries in recent years (Chapter 4). The inclusion of disaster risk in these instruments and shock-financing mechanisms can have a significant impact on reducing uncertainty, potentially unlocking higher private investment, employment and growth (Chapter 7). Implementing a structured process for risk detection in the balance sheet can potentially provide a "price signal"; in contrast, a focus on *ex-post* disaster management offers little in the way of risk awareness or stimulating risk reduction (Phaup and Kirschner 2010). This is the case in Mexico, where innovative financing arrangements have been initiated under National Disaster Fund to incentivise investment, to "build back better" and relocate housing to lower-risk areas (Hoflinger et al. 2012).

One example of a strategic DRM response that incorporates the triple dividend concept is the fiscal risk matrix. Such matrices combine the assessment of many different contingent risks, including their interaction with disaster risk, and their use has grown from insights gained during recent financial and fiscal crises (Chapters 4 and 7). Fiscal risks are "stress-tested" through sensitivity tests on baseline macro and fiscal indicators. There is also a growing understanding of the need to take a systematic perspective in understanding the potential for complex and interrelated shocks, leading to a multi-risk approach (WEF 2015). Disaster risk has come to be considered a key threat; in a recent survey regarding relevant fiscal risks in Organisation for Economic Co-operation and Development countries, disasters emerged as an important concern (Kopits 2014).

In the future, the benefits of lower background risk may also be reflected in businesses and governments' access to affordable credit. Noting the growing influence of climate change on risks, Standard and Poor's suggest climate change could feed through to sovereign creditworthiness through economic, fiscal and external performance (Standard & Poor's Rating Services 2014). Credit rating agencies have also recognised that companies' credit profiles may be determined to a larger degree in the future by climate-related disasters and the increased exposure of companies and their global supply chains to risk (Moody's 2015; Standard & Poor's Rating Services 2015). In some cases, credit rating agencies have explicitly called for DRM strategies to both prevent disaster losses and maintain credit ratings, illustrated in coastal cities in south-eastern Virginia's Hampton Roads region of the US (Moody's 2015). Access to credit to enable capital investment may therefore provide a component of the development dividend for firms, with ratings agencies now calling for greater disclosure of firms' exposure to extreme natural hazards, which should encourage them to bolster their resilience to these events and aid transparency (Standard & Poor's Rating Services 2015).

1.5. The third dividend of resilience: Co-benefits of DRM investments

Generating development co-benefits (the third dividend of resilience)

DRM investments have multiple uses, which can be classified as economic, social and environmental co-benefits. These co-benefits may be either explicitly designed into the investment (such as dual-use infrastructure) or incidental.

While the nature of co-benefits varies significantly, they all materialise even in the absence of a disaster. Co-benefits can play an important role in motivating DRM measures and determining their design. Multi-purpose design that intentionally integrates these co-benefits can save money and significantly improve the attractiveness of investing in DRM.

These co-benefits include:

- Economic co-benefits (e.g. flood protection supporting fisheries)
- Social co-benefits (e.g. improved transparency or social cohesion)
- Environmental co-benefits (e.g. watershed protection).
- Economic co-benefits (e.g. flood protection supporting fisheries)
- Social co-benefits (e.g. improved transparency or social cohesion)
- Environmental co-benefits (e.g. watershed protection)

To gain a complete picture of the benefits of DRM investments, we must take into account their social, environmental and economic contexts. This makes it evident that DRM measures can yield a variety of co-benefits. These can materialise even in the absence of a disaster, but—unlike the second dividend of resilience—are not because of reduced background risk. In line with growing efforts to highlight the co-benefits of climate change mitigation, it is critical for decision-makers to fully understand and account for the co-benefits of DRM and climate change adaptation measures (Chapter 3; Global Commission on the Economy and Climate 2014; Kok et al. 2008; Santucci 2015). As emphasised above, it is important that the design of DRM measures also fully consider and mitigate the potential negative side-effects of DRM measures (such as the costs of relocation of communities from risky areas).

This section presents evidence of the positive side-effects, or co-benefits, of DRM measures. Some of these might be unintentional and generated as "spill-over" effects. However, the examples below also demonstrate the diverse synergies that can be created by intentionally designing measures to deliver both DRM and development objectives. Conversely, linking with DRM goals can also help deliver other benefits that might otherwise be undersupplied, such as public space or improved transport networks.

Multi-use design is becoming increasingly common in physical DRM infrastructure, where high upfront costs might otherwise make the investments harder to justify. Cyclone shelters in Bangladesh have a long history of multi-purpose design for use outside storm times (Khan 2008). In Tinputz district, Papua New Guinea, resilient infrastructure for education and health is designed both as a space for communal gatherings and as safe shelters for the community if disaster does strike (Tinputz District Disaster Risk Management Committee 2014).

Table 1.3 presents examples of the breadth of these co-benefits, illustrating how widely they can vary in practice. Some co-benefits can be directly observed, measured and quantified, such as livelihood benefits or dual purpose infrastructure; others, such as social cohesion, can be very hard to quantify and integrate in economic analyses, despite being potentially significant. Below, we outline three areas where DRM activities are delivering co-benefits: ecosystem-based approaches, transport systems and agricultural projects.

Table 1.3: The range of co-benefits associated with DRM measures

DRM activity	Possible co-benefits
Flood protection structures	Provision of irrigation or potable water and hydro-electric power Dual-purpose road infrastructure
Strengthening DRM capacity of civil society	Improved governance, more organised social structures
Ecosystem-based DRM approaches	Environmental conservation, improved air quality, climate change mitigation
Shelters	Community facilities (e.g. clinics or schools) in non-disaster periods
Improving water supply systems in rural areas	Water supply systems improved regardless of a disaster occurring

Construction and use of drainage pipes, canals and water retention basins	Improved irrigation practices, possibly improved agricultural practices Dual purpose road tunnel or parking lot infrastructure
Community-based disaster preparedness	Improved women's involvement in community-level activities
Installing more resilient wireless communications	Enhanced access to telephony and electronic data services
Training farmers to diversify the use of crops	Reduced vulnerability to poverty
Better monitoring of food supplies	Improvement to the food supply chain, possibly making it more cost-effective

Source: Adapted from ERM and DFID (2005).

1.5.1 Ecosystem-based co-benefits

Ecosystem-based approaches to DRM and climate adaptation provide a good illustration of co-benefits from investing in resilience. These have gained popularity in recent years, emphasising how good stewardship of environmental systems can help reduce and adapt to disaster risks, in turn saving lives and reducing loss and damage. At the same time, ecosystem protection can generate wider social and environmental co-benefits, even in the absence of disaster events. These include:

- Biodiversity conservation
- Carbon sequestration and mitigation
- Land erosion and degradation prevention
- Habitat creation and restoration
- Mitigation of microclimate variability

Social co-benefits include:

- Improved and secure livelihoods
- Social cohesion and community
- New or preserved recreation areas
- Better quality land for agriculture/livestock
- Better water security

Aside from economic damages, these approaches have been shown to help develop new or improved income, profits or savings, when compared with alternative DRM or climate adaptation approaches (Doswald et al. 2014). The services delivered by ecosystems can therefore not only deliver disaster risk reduction benefits such as flood regulation and protection from storm-surge protection but also enhance food security, provide sustainable water supplies or enhance livelihoods through increasing resource-use options or tourism (Jones et al. 2012).

A Vietnam mangrove plantation and DRM project in the typhoon- and flood-prone coastal provinces of northern Vietnam has proven to have significant environmental co-benefits (IFRC 2012). The benefits of this multi-purpose DRM project include carbon sequestration, nutrient retention, sediment retention, biodiversity habitat, flood attenuation, wastewater treatment and water supply and recharge. The 17-year-long project cost $8.88 million to set up and has involved the creation of 9,462 ha of forest (8,961 ha of mangroves) in 166 communes and the "protection of approximately 100km of dyke lines". The project aims to reach approximately 350,000 beneficiaries directly and 2 million indirectly. There has been an "increase in per hectare yield of aqua culture products such as shells and oyster by 209-789 per cent". Economic benefits from aqua product collection and honeybee farming are found to be between $344,000 and $6.7 million in the selected communes. Environmental benefits include $218 million alone generated as an estimated minimum of CO_2 emissions absorbed by the planted mangroves (assuming a price of $20/t CO_2e).

Such multi-purpose water management approaches can therefore be designed to provide livelihood, environment, aesthetic or recreational co-benefits alongside disaster resilience. The Netherlands' Room for the River is being designed to manage higher water levels, giving the country's rivers more space to flood safely. The measures also attempt to improve the quality of the immediate surroundings, such as providing new river islands. While in some cases such co-benefits can be assumed to represent good project design and implementation, they are not always costed into the business cases that justify the financing decisions.

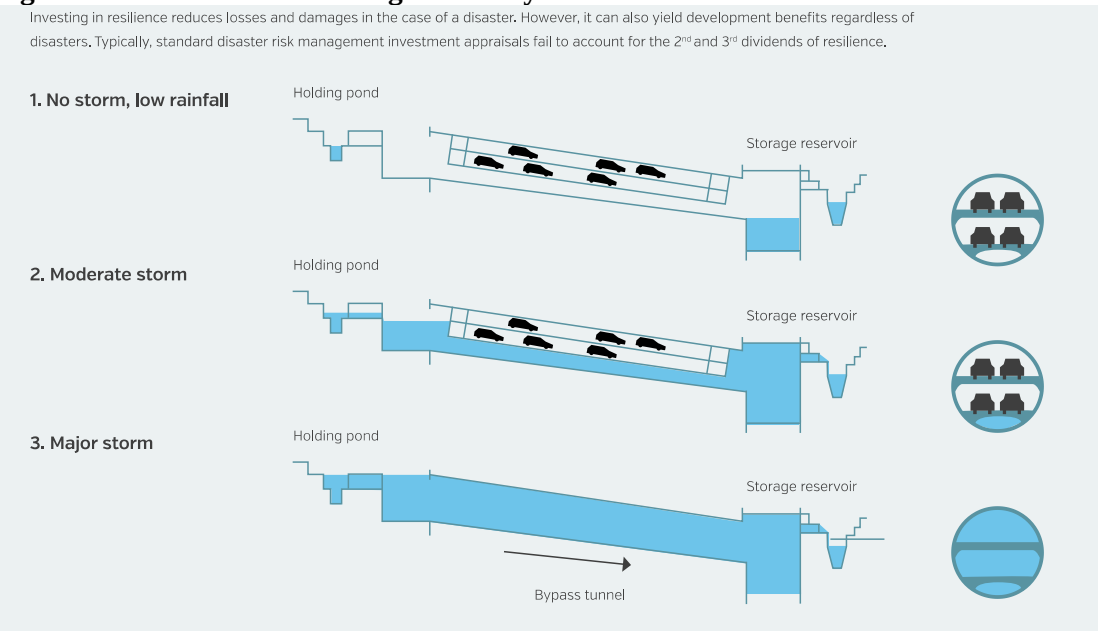
Similarly, the World Bank's flood management programme in Sri Lanka's capital Colombo demonstrates the wider value of wetland protection and restoration beyond just flood defence. While performing a valuable role in reducing flood risks, the wetlands of the Colombo basin serve a range of other purposes. They provide livelihoods and economic security to local residents through fishing and rice cultivation, while also serving as a park area for tourism and recreation, and the wetlands and surrounding areas are on average 10 °C cooler than non-pervious areas (such as parking zones or the streets) at the hottest time of the day. This results in energy savings for buildings and homes using artificial cooling systems. Other wetland co-benefits include waste water treatment, maintenance of freshwater supplies, carbon sequestration, climate regulation, water regulation, soil erosion regulation, pollination, recreation and nutrient cycling. Economic analyses of selected wetland co-benefits, including flood protection, carbon sequestration, climate regulation through reduced use of air conditioning near wetland areas and waste water treatment, along with potential income from recreational activities, could be worth $113–127 million annually (World Bank 2015).

1.5.2 Transport co-benefits

DRM investments can also be linked with transport systems to combine objectives and improve efficiency. Flood embankments are often used not only to protect the landward assets from inundation but also to support road networks. In doing so, the roads themselves are also more resilient to flood impacts and can permit movement after major hazard events. These synergies can operate at a variety of scales: levees in Bangladesh commonly support small-scale tracks for rickshaws and motorcycles, whereas the 11 dams that protect St Petersburg in Russia against storm surges are built to support 25.4 km of six-lane highway.

The Smart Tunnel scheme in Kuala Lumpur combines storm water flood drainage with vehicle tunnels under the city (see Figure 1.5). For Category 2 storms, which occur about 10 times each year, part of the flood waters are diverted through the lower section of the road tunnel. For Category 3 storms, which occur once or twice a year, traffic is prohibited and a large part of the flood flow is diverted through the tunnel. A flood detection system provides adequate warning time to evacuate traffic and operate tunnel floodgates as well as to minimise the cost of traffic disruption (Seang 2009).

Figure 1.5: SMART tunnel design in Malaysia



1.5.3 Agricultural co-benefits

The development of safe sea port shelters as part of the Natural Disaster Risk Management Project in Vietnam were planned to support the sustainable development of the fishing industry. The facilities are highly effective in preventing storm damages for the fishery boats, but also provide a centre for the development of fisheries logistic services. As well as fewer risks to boats related to storms, fisheries business now have a more adequate infrastructure, electricity, water, transportation and other logistics services for their activity (World Bank 2014b).

The World Bank Mekong Integrated Water Resources Management Project has produced a number of economic co-benefits. Estimates of these are based on the assumption that they would be fully reached in three years and that the economic life of the investment would be 15 years. The project was designed with water resource management and flood plain management at its core and resulted in the rehabilitation of 10 floodgates in the Xebangfai River and about 40 village irrigation schemes being put in place in the Xebangfai and Xebanghieng rivers of Lao PDR.

Table 1.4: Summary of floodgate rehabilitation activities

	Required works	Estimated financial cost ($)	Estimated economic cost ($)	Benefit area (ha)	Estimated flood protection benefit ($)	Estimated fish benefit ($)	Total benefit ($)
Huay Pin	Rehabilitation of the mechanical works (gates), minor structural repairs to the headworks	72,000	68,400	120	12,375	3,600	15,975
Huay Kae	Rehabilitation of the mechanical works (gates), minor structural repairs to the headworks	52,500	49,875	100	10,313	3,600	13,913

Huay Pa Pak	Rehabilitation of the mechanical works (gates), minor structural repairs to the headworks	35,000	33,250	100	10,313	3,600	13,913
Huay Bung Or	Rehabilitation of the mechanical works (gates), resectioning of the canal (2.5 km)	31,875	30,281	150	15,469	3,600	19,069
Huay Daeng	Rehabilitation of the mechanical works (gates), resectioning of the canal (3.0 km)	38,250	36,338	170	17,531	3,600	21,131
Total			218,144	640	66,000	18,000	84,000

Source: World Bank (2012).

The floodgate rehabilitation increased flood protection (avoiding losses associated with the first dividend of resilience) for 640 ha of cultivated areas, and, on average, $13,200 of flood protection benefits per gate. In addition, co-benefits (the third dividend of resilience) included increased fish catch in the floodplain, with the average annual benefit of the increased fish catch estimated at $3,600 per gate, not only because of reduced flooding but also because of enhanced water regulation throughout the year (see Table 1.4). Increases in water use efficiency also produced co-benefits in the form of decreased electricity costs of $2/ha (World Bank 2012).

In Jamaica, the agriculture sector contributes about 6% of GDP and employs 17-18% of the labour force. Domestic agriculture is largely located on hillside plots, with an average size of 1 acre with slopes above 15 degrees; meanwhile, the export agriculture (including coffee, banana, cacao and coconut) contributes to 22% of total exports, raising $274 million in foreign exchange each year. A number of DRM programmes have focused on this sector, including the Jamaica Rural Economy and Ecosystems Adapted for Climate Change (JaREEACH) programme, which aims to strengthen local and national institutional capacity to support climate change adaptation and DRM within agriculture. The Planning Institute of Jamaica has also committed $9.9 million to the development and implementation of adaptation measures, focusing on strengthening agricultural productivity, coastal protection and building local capacity for natural resource management

Of these investments, those that have focused on reducing drought risk in farming seem to offer particularly high potential for co-benefits. The installation of dedicated irrigation systems to overcome the impact of drought has helped farmers increase their productivity and output as well as reduce soil erosion and deforestation by optimising previously inefficient farming practices (see Box 1.1).

Box 1.1: Key co-benefits of integrated DRM investments in Jamaican agriculture

Economic co-benefits: DRM irrigation projects helped reduce the economic impacts of droughts, particularly in Southern Clarendon and St Elizabeth. These farming communities have also benefited from increased productivity and output relative to other areas, even in the face of drought over the April–June quarter in 2014.

Social co-benefits: Training and shared learning on drip irrigation have strengthened social capital and built comradeship within the communities, especially among the farmers in the field.

Environmental co-benefits: A rainwater catchment tank and drip irrigation system in Lititz, St Elizabeth, has improved small-scale irrigation, resulting in higher yields, less soil erosion and deforestation and an increase in socioeconomic status for farmers.

Sources: Interviews with Ministry of Agriculture and Development Bank of Jamaica; Planning Institute of Jamaica (2007); UNDP Jamaica (2012).

1.6. Concluding recommendations for decision-makers: Integrating the triple dividend of resilience in DRM appraisals

Realising the triple dividend of resilience involves a strategic shift, offering a different perspective on how investments can support policies and objectives beyond DRM. The approach offers an enhanced understanding of the broader economic, social and environmental implications of investing in DRM activities. While loss data, risk models and appraisal tools are the key means for investment decision-making, the overarching foundation of the triple dividend of resilience concept is a more holistic strategy that links DRM, climate and other development policy objectives. DRM is not seen as an objective in its own right—it is considered an important lever for strategic risk management of overall development progress that reduces avoided losses and yields benefits from taking risks.

This approach starts with thinking through development strategies and the inherent dynamics of economic development. It then requires the stress-testing of these strategies, based on a range of possible climate futures and the principles of avoiding locking in development paths that are, or may become, unsustainable under climate change.

In practical terms, when making development and DRM plans, policy-makers should resist the temptation (and analytical convenience) of relying on a single set of parameters for analysing risks, costs and benefits. The characteristics of risk are often context-specific and the requirements for assessment differ between local or national scales. Similarly, for hazards with a high probability of recurrence, the measurement of benefit and cost calculations may prove less problematic than for hazards with low and uncertain probabilities (such as earthquakes). We therefore suggest applying multiple approaches and not relying on a single assessment. By way of a conclusion, the following steps indicate some relevant guidance for decision- makers to move towards the triple dividend of resilience perspective (Garrido 2015).

1.6.1 Define the problem and its context

A practical starting point for decision-makers is a mapping exercise to understand development goals, threats and risk drivers.

- What are the contextual development goals set by a certain country, city, locality or village?
- What are the threats to, and drivers of, development?
- What DRM measures are proposed and how do they relate to these goals, threats and drivers?
- Who are main beneficiaries? To what extent are individuals, groups, sectors or activities better protected because of DRM?

1.6.2 Identify and apply tools and methods for empirical analysis of DRM

Ideally, a DRM proponent should strive to select a set of approaches that can generate quantitative measures or shed light on each of the three types of dividends of resilience. It is unlikely that a single approach can yield answers to every single benefit stream linked to DRM. A more complete evaluation requires the use of various qualitative and quantitative assessment tools. The application of multiple approaches rather than reliance on one tool or method is recommended, especially in data-constrained environments, where flexible approaches are needed.

- Conducting a probabilistic assessment rather than relying only on historic loss figures can yield clearer understanding of the first dividend (saving lives and avoiding losses).
- The biggest gap in triple dividend knowledge lies in understanding how reducing background risk can help unlock and stimulate economic activity. Using simple proxies to measure the second dividend of resilience may be necessary. Anticipated land value increase could be used as a good estimate of increased economic activity in a given project area, for example. Another more sophisticated option would be to identify risk thresholds and acceptable levels of risks for different stakeholders.
- The economic value of dual-purpose infrastructure, as well as possible cost savings, can be used to measure the value of the third "co-benefits" dividend. Assessments to monetise non-market values may also be required to widen the scope of assessments of social and environmental co-benefits.

1.6.3 Communicate outcomes

Communicating the triple dividend assessments to other stakeholders, such as business, tax payers and political supporters, is an essential requirement for integrating the concept into development planning:

- Communicate how DRM interventions are linked to, or can be delivered through, other development policies and interventions. Explain the benefits of DRM actions using triple dividend principles and the value of DRM interventions relative to "do nothing" scenarios.
- Appropriate strategies should focus on supporting development paths that are robust to a range of possible climate and socioeconomic futures. Recognising the need to integrate DRM into future development pathways, to curb the rise of disaster losses, constitutes an important step towards achieving sustainable development objectives.
- Devise strategies for communicating the dividend concept. This includes communicating how DRM interventions are linked, or can be delivered through, other development interventions. What are the benefits from DRM under triple dividend principles and are they robust under different climate and development futures? What is the value of DRM interventions relative to "do nothing" scenarios?
- Identify the implications of fear and risk aversion. The experience of a disaster and the ever-present background risk of future disasters can hamper development and cause economic paralysis. The biggest gap in triple dividend knowledge is in understanding how mitigating such background risk can help unlock and stimulate economic activity. While quantification of these effects is highly case-specific, one option would be to identify risk thresholds and acceptable levels of risks for different stakeholders.

References

Auker, Melanie, Robert Sparks, Lee Siebert, Helen Crosweller and John Ewert. 2013. "A Statistical Analysis of the Global Historical Volcanic Fatalities Record." *Journal of Applied Volcanology* 2 no. 2: doi 10.1186/2191-5040-2-2.

Carter, Michael and Christopher Barrett. 2006. "The Economics of Poverty Traps and Persistent Poverty: An Asset-Based Approach." *The Journal of Development Studies* 42 no. 2: 178–99.

CDP (Carbon Disclosure Project). 2015. *Climate Change Resilience in Europe: A Snapshot of the Private Sector*. London: CDP.

Crawford, Meg. and Stephen Seidel. 2013. *Weathering the Storm: Building Business Resilience to Climate Change*. Arlington, VA: Center for Climate and Energy Solutions.

Dar, Manzoor, Alain de Janvry, Kyle Emerick, David Raitzer and Elisabeth Sadoulet. 2013. *A Flood of Investments: Flood-Tolerant Rice and Farm Investment in India*. Berkley, CA: University of California.

Dercon, Stefan (ed.). 2005. *Insurance against Poverty*. Oxford: Open University Press.

Díaz-Perera, Miguel Ángel. 2013. "La construcción de las condiciones históricas de posibilidad de un desastre: el caso de dos colonias de Villahermosa, Tabasco", Final report of FORDECYT Cuenca Grijalva Project. Villahermosa, Mexico: El Colegio de la Frontera Sur.

Doswald, Nathalie, R. Munroe, Dilys Roe, Alessandra Giuliani, Ivan Castelli, J. Stephens, Iris Moller, Tom Spencer, Bhaskar Vira and Hannah Reid. 2014. "Effectiveness of Ecosystem-Based Approaches for Adaptation: Review of the Evidence-Base." *Climate and Development* 6 no. 2: 185–201.

Elbers, Chris, Jan Willem Gunning and Bill Kinsey. 2007. "Growth and Risk: Methodology and Micro Evidence." *World Bank Economic Review* 21 no. 1: 1–20.

Emerick, Kyle, Alain de Janvry, Elisabeth Sadoulet and Manzoor Dar. 2015. *Technological Innovations, Downside Risk, and the Modernization of Agriculture*. Cambridge, MA: Poverty Action Lab.

ERM (Environmental Resources Management) and DFID (Department for International Development). 2005. *Natural Disaster and Disaster Risk Reduction Measures. A Desk Review of Costs and Benefits.* London: ERM.

Field, Christopher, Vicente Barros, Thomas Stocker, Qin Dahe, David Jon Dokken, Kristie L. Ebi, Michael D. Mastrandrea, Katharine J. Mach, Gian-Kasper Plattner, Simon K. Allen, Melinda Tignor and Pauline M. Midgley (eds). 2012. "Summary for Policy Makers." In *Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation: Summary for Policymakers*. Report of Working Groups I and II of the IPCC. Cambridge and New York: Cambridge University Press.

Fleisher, Belton and Jian Chen. 1997. "The Coast–Noncoast Income Gap, Productivity, and Regional Economic Policy in China." *Journal of Comparative Economics* 25 no. 2: 220–36.

Gallup, John, Jeffrey Sachs and Andrew Mellinger. 1998. *Geography and Economic Development.* Working Paper 6849. Cambridge, MA: NBER.

Garrido, L. 2015. "Ideas towards the Building Guidelines for Quantitative Analysis of DRMR". Unpublished discussion note to GFDRR, World Bank.

GFDRR (Global Facility for Disaster Reduction and Recovery). 2014. "Building Back Better in Tonga after Cyclone Ian." Stories of Impact Briefing. Washington, DC: World Bank.

GFDRR (Global Facility for Disaster Reduction and Recovery). 2015. *Investing in Resilience*. Washington, DC: World Bank.

Ghesquiere, Francis, Luis Mahul and Olivier Jamin. 2006. *Earthquake Vulnerability Reduction Program in Colombia: A Probabilistic Cost-Benefit Analysis*. Policy Research Working Paper. Washington, DC: World Bank.

Global Commission on the Economy and Climate. 2014. *New Climate Economy Technical Note: Infrastructure investment needs of a low-carbon scenario*. Washington, DC: Global Commission on the Economy and Climate.

Global Commission on the Economy and Climate. 2015. *Seizing The Global Opportunity, The New Climate Economy Report 2015*. Washington, DC: Global Commission on the Economy and Climate.

Gollier, Christian and John Pratt. 1996. "Risk Vulnerability and the Tempering Effect of Background Risk." *Econometrica* 64 no. 5: 1109–23.

Greatrex, Helen, James Hansen, Samantha Garvin, Rahel Diro, Sari Blakeley, Margot Le Guen, Kolli Rao and Daniel Osgood. 2015. *Scaling up Index Insurance for Smallholder Farmers: Recent Evidence and Insights.* Report 14. Copenhagen: CCAFS.

Hallegatte, Stéphane. 2014 *Economic Resilience: Definition and Measurement*. Policy Research Working Paper 6852. Washington, DC: World Bank.

Hoflinger, Rubern, Olivier Mahul, Ghesquiere, Francis and Salvador Perez. 2012. *FONDEN: Mexico's Natural Disaster Fund – A Review*. Washington, DC: World Bank.

IFRC (International Federation of Red Cross and Red Crescent Societies). 2012. *Mangrove Plantation in Viet Nam: Measuring Impact and Cost Benefit.* Case Study. Geneva: IFRC.

Jones, Holly, David Hole and Erika Zavaleta. 2012. "Harnessing Nature to Help People Adapt to Climate Change." *Nature Climate Change* 2 no. 7: 504–9.

Keefer, Philip. 2009. Disastrous Consequences: The Political Economy of Disaster Risk Reduction. Working Paper. Washington, DC: World Bank.

Kellett, Jan and Alice Caravani. 2014. *Financing Disaster Risk Reduction: A 20 Year Story of International Aid*. London: ODI.

Khan, M. Shah Alam. 2008. “Disaster Preparedness for Sustainable Development in Bangladesh.” *Disaster Prevention and Management: An International Journal* 17 no. 5: 662–71.
Kok, Marcel, Bert Metz, Jan Verhagen and Sascha van Rooijen. 2008. “Integrating Development and Climate Policies: National and International Benefits.’ *Climate Policy* 8 no. 2: 103–18.
Kopits, George. 2014. “Coping with Fiscal Risk.” *OECD Journal on Budgeting* 14 no. 1: 47–71.
Lovell, Emma and Virginie le Masson. 2014. *Equity and Inclusion in Disaster Risk Reduction: Building Resilience for All*. London: CDKN and ODI.
Lovett, Richard. 2010. “Why Chile Fared Better than Haiti.” Nature Briefing, 10 March. London: Nature Publishing Group.
Madajewicz, Malgosia, Asmelash Tsegay and Michael Norton. 2013. *Managing Risks to Agricultural Livelihoods: Impact Evaluation of the HARITA Program in Tigray, Ethiopia, 2009-2012*. Evaluation Report. Boston, MA: Oxfam America.
Mechler, Reinhard and Laurens Bouwer. 2015. “Understanding Trends and Projections of Disaster Losses and Climate Change: Is Vulnerability the Missing Link?” *Climatic Change* 133 no. 1: 23–35.
Moody’s. 2015. “Flood Risk in Coastal Virginia Supports Need for Proactive Planning, Capital Investments.” Announcement, 18 June. New York: Moody's.
Patankar, Archana. 2015. *The Exposure, Vulnerability, and Ability to Respond of Poor Households to Recurrent Floods in Mumbai*. Policy Research Working Paper 7481. Washington, DC: World Bank.
Peterson, George. 2012. “Unlocking Land Values to Finance Urban Infrastructure.” PPIAF Trends and Policy Options 7. Washington, DC: World Bank.
Phaup, Marvin and Charlotte Kirschner. 2010. “Budgeting for Disasters: Focusing on the Good Times.” *OECD Journal on Budgeting* 2010 no. 1: 1–24.
Planning Institute of Jamaica. 2007. *The Poverty-Environment Nexus: Establishing an Approach for Determining Special Development Areas in Jamaica*. Kingston: Sustainable Development and Regional Planning Division, Planning institute of Jamaica.
Rentschler. Jun. 2013. *Why Resilience Matters: The Poverty Impacts of Disasters*. Policy Research Working Paper 6699. Washington, DC: World Bank.
Rodin, Judith. 2014. *The Resilience Dividend: Being Strong in a World Where Things Go Wrong*. Washington, DC: Public Affairs.
Rogers, David and Vladimir Tsirkunov. 2011. “Costs and Benefits of Early Warning Systems.” Background Paper for Global Assessment Report. Geneva: UNISDR.
Santucci, Lorenzo, Ingo Puhl, Abu Sinha, Iftekhar Enayetullah and William Agyemang-Bonsu. 2015. *Valuing the Sustainable Development Co-Benefits of Climate Change Mitigation Actions*. Bangkok: UNESCAP.
Scor SE. 2013. “Supply Chain and Contingent Business Interruption (CBI): A Perspective on Property and Casualty.” Scor Global P&C Focus, December. Paris: SCOR SE.
Seang, Hin. 2009. “A Case Study of Mitigating Flooding in City Center of Kuala Lumpur.” In *Innovative Strategies towards Flood Resilient Cities in Asia-Pacific.* Bangkok: UNESCAP.
Shepherd, Andrew, Tom Mitchell, Kirsty Lewis, Amanda Lenhardt, Lindsey Jones, Lucy Scott and Robert Muir-Wood. 2013 *The Geography of Poverty, Disasters and Climate Extremes in 2030.* London: ODI.
Standard & Poor’s Rating Services. 2014. *Special Report: Climate Change. Preparing for the Long Term. Standard & Poor’s Ratings Services: Credit Week, The Global Authority on Credit Quality. 28 May 2014*. New York: Standard & Poor’s Rating Services, McGraw Financial.
Standard & Poor’s Rating Services. 2015. *Climate Change Will Likely Test the Resilience of Corporates' Creditworthiness for Natural Catastrophes. Ratings Direct. 20 April 2015*. New York: Standard & Poor’s Rating Services, McGraw Financial.
Subbiah, Lolita Bildan and Ramraj Narasimhan. 2008. “Assessment of the Economics of Early Warning Systems for Disaster Risk Reduction.” Background Report submitted to GFDRR. Bangkok: Regional Integrated Multi-Hazard Early Warning System, Asian Disaster Preparedness Center.
Surminski, Swenja. 2014. “The Role of Insurance in Reducing Direct Risk: The Case of Flood Insurance.” *International Review of Environmental and Resource Economics* 7 no. 3-4: 241–78.

Tanner, Thomas, David Lewis, David Wrathall, Robin Bronen, Nicholas Cradock-Henry, Saleemul Huq, Christopher Lawless, Raphael Nawrotzki, Vivek Prasad, Md. Ashiqur Rahman, Ryan Alaniz, Katherine King, Karen McNamara, Md. Nadiruzzaman, Sarah Henly-Shepard and Frank Thomalla. (2015) "Livelihood resilience in the face of climate change", *Nature Climate Change* 5: 23–26.

The Economic Times. 2011. "Honda to Cut Production at Indian Arm by Half." *The Economic Times*, 26 April.

Tinputz District DRM Committee. 2014. "Tinputz District Disaster Risk Management Plan". Tinputz: Tinputz District DRM Committee.

Tran, Van G.P. 2013 *Lessons from Typhoon Nari. Storm Resistant Housing Shown To Be Effective.* Hanoi: Institute for Social and Environmental Transition-International.

UNDESA (UN Department of Economic and Social Affairs). 2014. *Revision: World Urbanization Prospects*. New York: UNDESA.

UNDP (UN Development Programme) Jamaica. 2012. *Water is Life: Empowering St. Elizabeth Farmers*. UNDP Stories. Kingston: UNDP Jamaica.

UNISDR (UN Office for Disaster Risk Reduction). 2015a. *Making Development Sustainable: The Future of Disaster Risk Management. Global Assessment Report on Disaster Risk Reduction*. Geneva: UNISDR.

UNISDR (UN Office for Disaster Risk Reduction). 2015b. "Chile's Investment in Disaster Risk Reduction Pays off." News Archive, 17 September. Geneva: UNISDR.

WEF (World Economic Forum). 2015. *The Global Risks Report 2015*. Davos: WEF.

Wilkinson, Emma. 2012. *Transforming Disaster Risk Management: A Political Economy Approach*. Working and Discussion Papers. London: ODI.

World Bank. 2012. "Mekong Integrated Water Resources Management Project. Project Appraisal Document." Washington, DC: World Bank.

World Bank. 2013. *World Development Report 2014. Risk and Opportunity: Managing Risk for Development*. Washington, DC: World Bank.

World Bank. 2014a. "A Novel Approach to Disaster Risk Management: The Story of Mexico." Washington, DC: World Bank.

World Bank. 2014b. |Implementation Completion and Results Report, Vietnam Natural Disaster Risk Management Project." Washington, DC: World Bank.

World Bank. 2015. *Global Monitoring Report 2015/2016*. Washington, DC: World Bank.

WRI (World Resources Institute). 2008. *Roots of Resilience – Growing the Wealth of the Poor*. Washington, DC: WRI.