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Valuing the Resilience Dividend

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Executive Summary

Resilience is the ability of individuals, communities and, in general, systems to withstand disruptions. For centuries societies have focused on achieving high levels of resilience in order to bounce back and build back better effectively from man-made and natural disasters. Given the current environmental challenges, growing populations and increasing globalization, resilience has never been higher on the global agenda. However, resilience is much more than mere disaster preparedness. It is also about adding value to society irrespective of disasters. These value-adding benefits that arise from disaster preparedness but also exist in times of no disasters can be referred to as the Resilience Dividend. Infrastructure resilience is key to both main aspects of the Resilience Dividend: disruption preparedness and value-adding benefits irrespective of disasters.

The present study examines four concrete case studies in different cities throughout the world (Manila, Mathbaria, Quito, Port-au-Prince). The results indicate that the Resilience Dividend does exist and that investments in resilience do pay off. The methodology in this study is a combination of existing approaches – mainly the SuRe SmartScan and sector-specific indicators – to form one new, innovative approach. By analyzing case studies and combining the two approaches, this study marks the first steps towards indicating the Resilience Dividend in the case of a disaster and without.

At present, key decision makers in the infrastructure sector are lacking four main elements:

- Appropriate capacity building to raise awareness about the benefits of resilience and why it should therefore be fostered, measured and enhanced as part of the project development process.
- Technical assistance in the form of state-of-the-art expert knowledge on the ground and throughout the entire value chain and life cycle of an infrastructure project.
- An appropriate tool to gain insights into the Resilience Dividend and identify what they should look at, what they should benchmark their projects against, and which indicators they should use to snapshot resilience level assessments both periodically and after disasters.
- Data to prove that better adherence to resilience and sustainability features will yield better risk-return parameters such as better economic and financial performance.

Over time, the creation of an infrastructure project registry containing resilience, sustainability, financial and economic data will provide deeper insights into the characteristics of infrastructure resilience and help to unlock the money needed to close the infrastructure investment gap and foster overall resilience.

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Abbreviations

3GF	Global Green Growth Forum
ACCCRN	Asian Cities Climate Change Resilience Network
ADB	Asian Development Bank
BHC	Benpres Holdings Corporation
C40	Cities Climate Leadership Group
CBD	Convention on Biological Diversity
CCFLA	The Cities Climate Finance Leadership Alliance
CIA	Central Intelligence Agency
CRED	Centre for Research on the Epidemiology of Disasters
DENR	Department of Environment and Natural Resources
DFI	Development Finance Institution
EIB	European Investment Bank
ESG	Environment, Social, and Governance
ESIA	Environmental and Social Impact Assessment
ESMS	Environmental and Social Management System
FATF	Financial Action Task Force
FIDIC	International Federation of Consulting Engineers
FPIDC	First Philippine Infrastructure Development Corporation
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GIB	Global Infrastructure Basel Foundation
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GRI	Global Reporting Initiative
ICLEI	Local Governments for Sustainability
IDB	Inter-American Development Bank
IFC	International Finance Corporation
JICA	Japan International Agency Cooperation Agency
HIS	Institute for Housing and Urban Development Studies Rotterdam
ILO	International Labour Organization
IUCN	International Union for Conservation of Nature
ISEAL	International Social and Environmental Accreditation and Labelling Alliance
MDB	Multilateral Development Bank
MNE	Multinational Corporation
MNTC	Manila North Tollways Corporation
M&E	Monitoring and Evaluation
NLEX	North Luzon Expressway
ODI	Overseas Development Institute
OECD	Organisation for Economic Co-operation and Development
OH&S	Occupational Health and Safety
PNCC	Philippine National Construction Corporation
PPP	Public-Private Partnership
R20	Regions of Climate Action
RPA	Regional Plan Association
SDG	Sustainable Development Goal
SRBA	Sustainability and Resilience Benefits Assessment
TA	Technical Assistance
UN	United Nations
UNFCCC	United Nations Framework Convention on Climate Change
UNISDR	United Nations International Strategy for Disaster Reduction
USD	United States Dollar
WB	World Bank

WWF	World Wide Fund for Nature

1 Introduction

"As you become more adept at managing disruption and skilled at resilience building, you are able to create and take advantage of new opportunities in good times and bad. That is the resilience dividend."

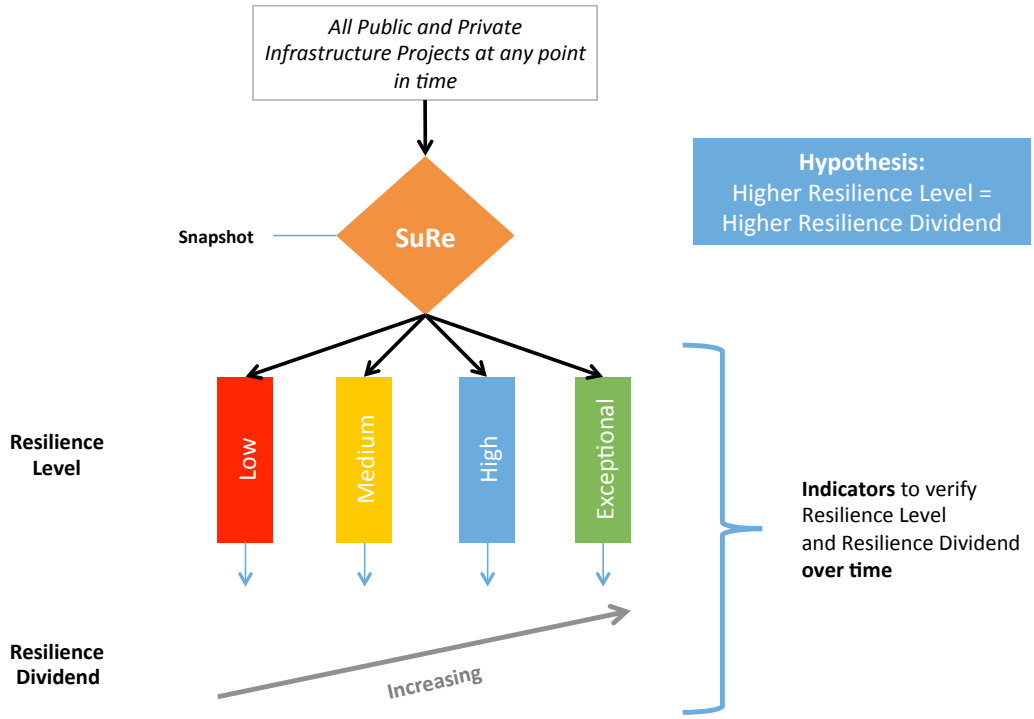
(Rodin, 2015, p. 4)

Resilience is an issue that is currently rising rapidly on the agenda of international organizations, city planners and various decision makers. It is clear that this topic cannot be neglected in times of increasing environmental challenges, growing populations and increasing globalization. While sustainability (often also referred to as "ESG", i.e. Environment, Social and Governance) topics have been the central issue of debate in this area for decades, resilience has emerged as a new term that is necessary to address the present and future issues which are gaining in importance. Even though sustainability and resilience share several overlapping themes, the latter can be clearly distinguished from the former due to its extensive emphasis on disruptions of various kinds. In this regard, resilience gives rise to benefits in the form of reduced losses after a disaster. However, resilience is more than disaster preparedness. It is also about adding value to society irrespective of disasters taking place. For instance, having a safe and stable sanitation system in place is not only necessary to avoid epidemics after a flood, but also of great use at any given time. These value-adding benefits that arise from disaster preparedness, but also exist during times with no disasters, can be referred to collectively as the Resilience Dividend, which forms the central focus of this study.

Current trends in economics, demographics and globalization are leading to increased migration to cities throughout the world. The resilience of an urban community is to a large degree determined by the quality and reliability of its infrastructure. This is why this study analyses the Resilience Dividend of individual infrastructure projects within cities. It understands infrastructure as being more than its mere physical characteristics, and explores the environmental, social and institutional conditions under which an infrastructure project is designed, constructed and operated. For instance: what interlinkage exists between social cohesion and infrastructure?

At present, an effective tool to measure the Resilience Dividend is missing. The approach introduced in this study – the combination of a snapshot assessment serving as benchmark, and the subsequent application of infrastructure-specific indicators – attempts to fill this gap. The SuRe SmartScan is an instrument that allows the sustainability and resilience levels of infrastructure projects to be assessed at a single point in time (the aforementioned 'snapshot') as shown in Figure 1 below. The higher the attested resilience level, the greater the number of benefits that should arise, and therefore the higher the Resilience Dividend. This hypothesis is tested by using the indicators that measure the benefits resulting from resilience efforts and investment over time, and then comparing them with the initial snapshot findings.

Figure 1 Resilience measurement using the SuRe SmartScan and indicators



Source: GIB Foundation

Once the relationship between the resilience levels, as assessed by the SuRe SmartScan, and the benefits is confirmed, the SuRe SmartScan can be applied to future infrastructure projects. The resilience level will then indicate the Resilience Dividend that can be expected. This initial study, based on four case studies of infrastructure projects in different cities, reveals clear evidence that the Resilience Dividend exists. However, data availability is insufficient. This is why this study should not be seen as final, but rather as a starting point for further and deeper resilience research. In the future, resilience awareness raising via capacity building, and resilience implementation via technical assistance as early as possible in the infrastructure life cycle should root resilience thinking deeply in the minds of every stakeholder in the infrastructure industry. Moreover, a new resilience measurement tool, which combines the features in Figure 1, should be developed. It will give indications on what to look for and what to do in order to reach higher infrastructure resilience levels. This tool will employ the data obtained and provide the deepest possible insights into the issue of resilience and how to maximize the resilience of projects. Besides creating more resilient projects, these activities will allow resilience-specific project data to accumulate, which will then be entered into a project registry – a future database for proving the existence of the Resilience Dividend, and the gateway to obtaining funds to finance the enormous future infrastructure needs.

The remainder of this study is structured in the following way: Chapter 2 provides background information on resilience, Resilience Dividend as well as the particular importance of infrastructure for resilience. Chapter 3 develops the methodology of the study and provides the theoretical background. It presents the SuRe SmartScan as a central tool for the proposed attempt to measure resilience. The indicators as well as additional contributing tools and sources are also introduced. In Chapter 4, the combination of a snapshot resilience assessment and subsequent verification using indicators is applied to four infrastructure projects in Manila (Philippines), Mathbaria (Bangladesh), Quito (Ecuador), and Port-au-Prince (Haiti) respectively. Each case study is individually interpreted. In Chapter 5, based on the individual case study interpretations, an overall interpretation evaluates the extent to which the suggested approach is a reliable assessment methodology for resilience

and sustainability. Moreover, commonalities across the four projects and key lessons learned are discussed. This lays the basis for possible future steps, which are outlined in Chapter 6. Here, strategies and tools that should be developed in order to finally make the resilience of infrastructure not just a nice feature, but rather the “new normal” are emphasized. Chapter 7 concludes the study.

2 Background

In this chapter we provide background information and a literature review focusing on three main topics: first, we discuss the importance of sustainable and resilient infrastructure within a certain environment. Second, we present existing resilience dividend frameworks, and in the third part we focus on existing infrastructure resilience standards. This chapter provides the reader with a broad overview of sustainable and resilient infrastructure frameworks and outlines why they are important.

2.1 The Importance of Sustainable and Resilient Infrastructure

Infrastructure plays a critical role in the development of modern equitable societies, providing basic services such as energy, transportation, water and sanitation, as well as information and communications. According to the UN (2017), quality infrastructure relates positively to the achievement of social, economic and political goals. At the same time, inadequate and undeveloped infrastructure leads to a lack of access to markets, jobs and information, and can limit access to health care and education (ibid.).

Depending on the choice of infrastructure and how it is planned, constructed, operated and maintained, infrastructure can come at immense environmental and social cost. For example, fossil fuel based energy generation and transportation result in emissions that contribute to local air pollution and global warming, and thereby impact human health and well-being. At the same time, infrastructure is vulnerable to shocks and stresses. For instance, extreme weather events, partially due to climate change, risk weakening infrastructure and even threatening its very functioning and service provision. As a result, the unintended consequences of infrastructure on the environment and human health, as well as the resilience of infrastructure to natural hazards and man-made changes need to be factored in at the outset of any infrastructure development.

The World Risk Report (2016) states that when a natural or man-made disaster strikes, “infrastructure can be a deciding factor in whether or not the situation becomes a disaster”. For example, roads provide a crucial component for emergency services, relief services for affected communities, and evacuation routes in the event of a disaster (Pavement interactive, 2012). Rodrigue (2016) argues that an effective way to assess how critical an infrastructure is to analyze the impacts on the flows and activities of the infrastructure in the absence of it.

According to the US National Research Council (2009), economists generally agree that (1) infrastructure and critical infrastructure (i.e. infrastructure that is key for the functioning of a society at large) affect the behavior of people and businesses which influence economic growth, land use, and quality of life; and (2) without quality infrastructure, productivity will not reach high levels. Therefore, critical infrastructure systems can affect the following aspects of society (ibid.):

- The competitiveness of services and goods in the global market;
- The health, safety, and well-being of citizens;
- The availability and reliability of power and the maintenance of life-support systems;
- The travel time required for people to go from home to work or other destinations and for the efficient transport of goods and services;
- The reliability and speed of telecommunications;
- The speed and effectiveness of communications about actions to be taken during natural and human-made disasters (e.g. regarding evacuation and safe harbors);
- The time, cost, and extent of recovery for communities following such disasters.

Similar to Judith Rodin's (2015) idea of readiness, responsiveness and revitalization, infrastructure is important for communities in terms of their emergency preparedness, economic recovery and interdependencies (NACO, 2014). First, as previously mentioned, infrastructure interdependencies can affect other infrastructure systems – in the way a bridge functions as part of a whole road network – as well as communities, livelihoods, jobs and the national economy (Gallego-Lopez & Essex, 2016). Second, a disruption to the infrastructure lifeline influences a community's ability to recover, to bounce back and to build back better after and from a disaster. For example, in a region that is dependent on tourism, resilient roads, airports, railways and ports are key for the community to return to normal after a disaster. And third, emergency preparedness can limit the impacts of disasters. A prominent example of unprepared emergency planning can be found in the case of the terror attack in Norway in 2011, where a "lone wolf" terrorist was able to kill 77 and injure 319 people during several hours at two locations. Chapter 5 in *The Resilience Dividend* by Judith Rodin (2015) illustrates how the lack of human emergency preparedness played an important role in the fatal outcome of this attack. Rodin's Resilience Dividend framework is introduced in Section 2.2 below.

Box I

Why resilient infrastructure is important

"Sufficient and well-built infrastructure, such as high-quality power and transportation networks, can limit the impacts that natural hazards can cause both in terms of loss of life and economic damage. At the same time, the breakdown of nodal points in infrastructure, such as airports or power plants, can also cause impacts that reach far beyond the actual extent of the hazard. (…) We currently focus too much on short-term relief after disasters, and pay too little attention to ensuring that resilient infrastructure is in place before hazards occur" (Dr. Matthias Garschagen, Scientific Director of the World Risk Report, 2016).

2.2 Existing Resilience Dividend Frameworks

The assessment of resilience within economic, social and environmental systems has gained importance in recent years and in different academic fields. Assessing and evaluating resilience is essential for identifying possible risks, opportunities and alternatives to conventional management strategies (Liu, 2014; Quinlan et al., 2016; Sellberg, Wilkinson & Peterson, 2015). Moreover, the assessment and evaluation of resilience contributes to a better understanding of the needs and goals of complex systems, such as urban areas, and can shed light on the costs and benefits of interventions directed at increasing the level of resilience (Cutter, 2016). The assessment and evaluation of resilience is carried out using two approaches. First, top-down approaches are suitable for assessing spatial variability, allocating resources, and monitoring progress at state, national or international levels. Second, in contrast, bottom-up approaches have the potential to provide greater buy-in from communities, but at the same time do not allow comparisons between different locations due to the variability of data and differing meanings of resilience.

While most resilience frameworks naturally cover similar aspects, a variety of different frameworks are currently in use, each of them with its own particular perspective on the issue of resilience. The following paragraphs provide an outline of the most prominent approaches.

Judith Rodin provides a quite comprehensive framework of resilience and the Resilience Dividend arising from it. The definition of resilience is expressed in one sentence: "Resilience is the capacity of any entity – an individual, a community, an organization, or a natural system – to prepare for disruptions, to recover from shocks and stresses, and to adapt and grow from a disruptive experience (Rodin, 2015, p. 3)." However the Resilience

Dividend does not only come into existence when a disaster takes place. More than this "it is about achieving significant transformation that yields benefits even when disruptions are not occurring" (ibid., p. 4). To name a concrete measure, one could mention tree planting, which provides protection against erosion in the event of a catastrophe, but also increases biodiversity and air quality irrespective of disasters taking place. Rodin distinguishes five characteristics of resilience: being aware, diverse, integrated, self-regulating, and adaptive (ibid., p. 14). These characteristics summarize the kind of human organization and behavior that is necessary to better withstand catastrophes. It therefore becomes clear that the resilience of a society is considered from a systemic perspective as it depends on various complex interrelations between humans. Resilience does not measure the degree of permanent stability of a system, but rather the system's ability to absorb "change and disruption without the system collapsing or being totally thrown out of whack (…) and achieving some new state of stability" (ibid. p. 47).

The process of resilience building in a system takes the form of an adaptive cycle consisting of four parts: rapid growth, followed by conservation, then a disaster triggers a release phase, which gives rise to a stage of reorganization (Rodin, 2015, pp. 51–54). This build-back-better process should guarantee that the system always keeps on functioning and that reorganization reaches a higher level of resilience in every loop. Corresponding to the adaptive cycle are therefore three "phases of practice": readiness, responsiveness and revitalization (ibid. pp. 55–63).

Finally, while many disruptions are of the same kind as those centuries ago, newer factors that exacerbate hitherto disasters have come into play: urbanization, climate change, and globalization (Rodin, 2015, p. 70). This is why the present study focuses on infrastructure in cities – the place where disruptions have the greatest impacts.

The OECD (2014) provides another approach by defining a society's – monetary, physical but also immaterial – wealth as different types of capital stocks. The reference point is the OECD's (2014) concept of society's six capital stocks: financial, human, natural, physical, political and social capital respectively. The Resilience Dividend consists of benefits, and thus of increases in these six capitals. One can therefore say that the Resilience Dividend is the total of the changes in these six forms of capital. The overall dividend is thus divided into a financial, human, natural, physical, political and social dividend respectively.

Another framework that focuses more on the different components and the composition of the Resilience Dividend is the Triple Resilience Dividend approach of Tanner et al. (2015). According to them, there are three kinds of dividends (ibid. p. 14):

1) *The first dividend*: avoided losses when a disaster occurs. The losses include both short- and long-term impacts and comprise fatalities as well as damage to infrastructure. Reducing or avoiding these losses creates the part of the Resilience Dividend that is best known and conventionally referred to.

2) *The second dividend*: better disaster risk management, which reduces the amount of future losses. Economic risk decreases and investment prospects improve. Risk reduction therefore promotes innovation, investment and economic development, independent of whether disasters occur.

3) *The third dividend*: co-benefits. Investment in resilience yields additional benefits even when no disruption takes place. This is analogous to the benefits in a non-disaster situation mentioned by Rodin (2015) above.

Finally, there is the Lloyd's City Risk Index (Lloyd's, 2015), which provides another approach not covered by the aforementioned three frameworks. It has a rather narrow focus on resilience by calculating the share of economic activity that is jeopardized by potential disasters. In particular, the so-called "GDP@Risk" is an estimate of gross domestic product (GDP) losses that will occur in the defined time window from 2015 until 2025, given

there is a high likelihood that a number of disruptions will take place during this period. Therefore, it achieves a clear-cut result in dollar terms. Even though this framework ignores many important qualitative aspects, it contributes important insights into resilience at the city level.

The present study uses a synthesis of these frameworks. In a nutshell, it relies on Rodin's (2015) fundamental distinction between resilience in disaster and non-disaster situations. The additional component in the Triple Resilience Dividend approach concerned with future risk reduction (the 'second dividend') is not individually emphasized here, as it would require extensive additional research. However, given that the study takes into account investment conditions when investigating the Resilience Dividend in times of non-disruption, it includes the 'second dividend' at least to some extent. Moreover, the study refers to the OECD concept of six dividends. It is comprehensive, but nevertheless allows for a strict classification. In the specific case of the non-disaster resilience dividend, the Sustainability and Resilience Benefit Assessment (SRBA) approach enables some further specifications that are introduced below (see section 3.4). By using a combination of existing models, this study is able to analyze the project cases efficiently without neglecting important aspects. It has to be noted that the Lloyd's City Risk Index cannot be applied to individual infrastructure projects. But it can help embed the projects in its meso level conditions, and is therefore used as an introduction to the the case studies below.

2.3 Existing Infrastructure Resilience Standards

On the project level, many assessment tools regarding sustainability aspects already exist (Grafakos et al., 2016). Many of these sustainability assessment tools, however, do not properly address disaster risk reduction and climate change vulnerability aspects. Even though climate change risks in general, and risk reduction aspects in particular, are gaining importance in the literature, more research is needed regarding the assessment of disaster risk reduction and resilience aspects (Charoenkit and Kumar 2014).

However, many of the existing (sustainability) assessment tools for projects have only little concern for disaster resilience due to the comparatively low risk of natural disasters in developed countries, which is a result of the high quality of urban infrastructure and urban services there (Charoenkit and Kumar 2014). This results in a need, especially in low income or developing countries, to integrate resilience aspects into the existing sustainability assessment tools to allow for a comprehensive assessment of newly implemented infrastructure projects.

When it comes to evaluating the impacts of a project, it has to be recognized that there is no single method to use. In fact, complementing methods provide an even better picture of possible impacts. To evaluate impacts and define indicators for project evaluation, including projects that aim to enhance resilience, it is important to understand the type and the scope of the intervention, thus identifying the impact of what, on what and for whom. The cost and benefits of the implementation of a project are impossible to measure using one particular method (Leeuw and Vaessen 2009).

Moreover, the question of the "without the project" scenario has to be considered. Thus, the evaluation should take the baseline into account, if appropriate, and measure the effectiveness of the chosen pathway in relation to the 'do nothing' scenario (Pringle 2011). It is also difficult to measure the direct outcomes of an adaptation action, since it can also contribute to other aspects. Thus, knowing why certain benefits occurred is more important than the benefits per se (Pringle 2011). This can contribute to understanding the positive effects of a project in the complex system in which it is embedded. It becomes evident that adaptation actions should set baseline targets and indicators, monitor continuously during the implementation process and assess obstacles and improve them (Sanahuja 2011).

In particular, most of the infrastructure resilience standards have a narrow focus on the type and design of the infrastructure instead of using a holistic approach, or they even pay little attention to those issues (Rydge, Jacobs and Granoff, 2015; Gallego-Lopez & Essex 2016). Hence, Gallego-Lopez & Essex (2016) argue that building or changing infrastructure requires an overall approach regarding resilience (to both climate and disaster shocks) and sustainability (including climate change mitigation, the scale of resource use and the condition of ecosystem services). A different risk approach is needed before a specific design can be chosen (ibid.). To better illustrate the issue, Benson, Twigg and Rossetto (2007) in Gallego-Lopez & Essex (2016) outline two case studies in which the developers did not consider the overall approach:

- "Following widespread devastation caused by Hurricane Hugo in 1989, a new aid-funded hospital was built at the foot of a volcano in the Caribbean island of Montserrat. This hospital was subsequently destroyed by pyroclastic flows after the volcano began eruptive activity again in mid-1995" (p. 3).
- "Following the devastating 2004 Indian Ocean tsunami, some housing in Aceh, Indonesia, was reconstructed in flood-prone areas, leaving families vulnerable to future hazard events" (p. 3).

In other words, resilience in infrastructure should be a combination of the above-mentioned holistic approach to overall community/local-level resilience (e.g. long-term sustainability, livelihoods) and a detailed design of the infrastructure, rather than just a detailed design (e.g. physical risks) (ibid.). Furthermore, Gallego-Lopez & Essex (2016) explain that resilience in infrastructure can be achieved by engineering standards (design and layout), but increasingly requires a resilience-led approach.

In addition, Rydge, Jacobs and Granoff (2015) show how various sectors and their initiatives lack sufficient approaches regarding resilient and sustainable infrastructure. For example, the G20 Global Infrastructure Initiative focuses on improving infrastructure, but does not mention climate risks (ibid.). Furthermore, many countries have separate ministries for infrastructure policy and planning, and ministries for climate and disaster risk policies (ibid.). There is a clear lack of sustainability. On the other hand, multi-lateral development banks (MDBs) and development finance institutions (DFIs) have started including climate risks into their infrastructure investments. However, their efforts are also limited. The authors (2015) argue that DFIs and governments have to work more closely with the private sector to provide climate policy clarity. Moreover, partnerships with the insurance industry could also be beneficial, especially for governments. This is because the insurance sector is already a leader in terms of research to assess and manage climate risks (ibid.).

Three recommendations are outlined in the work of Rydge, Jacobs and Granoff (2015). First, the current approaches of governments, DFIs and the private sector to infrastructure planning and project assessment have to be re-assessed. Second, climate-smart infrastructure decisions have to be integrated at three levels: in the design and alignment of overall strategy and policy; in the composition and balance of infrastructure plans and portfolios considered as a whole; and in relation to individual projects. And third, G20 and other governments and DFIs should adopt, and encourage the private sector to adopt, two key principles: to include (1) risks of climate change over the whole life cycle, and (2) the goal of keeping average global warming to under 2°C.

Additionally, Lamhauge et al. (2012) argue that a better interaction between resilience/adaptation assessments on the local or project level, and assessments of the vulnerability on the country level, would be helpful. In turn, a framework could be created that incorporates the assessment of the achievements resulting from addressing specific needs of the people up to the "desired end results (countries' becoming less vulnerable to climate change)" (Lamhauge et al. 2012, p. 44). A combined assessment of actions aimed at resilience enhancement would provide information on the coherence of actions on different levels, the varying distribution of vulnerabilities as well as the overall performance of actions. This multi-level resilience assessment approach could enhance the knowledge of resilience at different scales including urban, community, and project levels.

In conclusion, the SuRe® Standard includes the previously mentioned recommendations in its approach. More on the details of the SuRe® Standard will be presented in the next chapter.

Box II

The importance of long-term infrastructure planning

When it comes to climate change, decisions made in the present have an impact on future risks. The lack of planning for climate risks has already undermined some public-private partnerships (PPPs). In 2008, for example, the World Bank (WB) affiliated International Finance Corporation (IFC) reviewed and helped finance the USD 2.3 billion expansion of the Panama Canal. Even though climate experts from IFC raised questions about the impact of the region's changing climate on the project, the project sponsors did not account for climate risks. As a result, the canal closed in December 2010 due to flooding, when Panama received more rain than at any time in its recorded history, causing significant disruptions and losses (World Bank, 2016).

3 Methodology

This chapter introduces the methodology that will be applied to the four project case studies. First, the basic theory of how resilience relates to inputs, benefits, disruptions, losses and risk is developed. Through this, it becomes apparent which measurement tools are needed to successfully test for the existence of the Resilience Dividend. The tools are presented in the subsequent sections: the central one is the SuRe SmartScan. To test and confirm its accuracy, a second instrument is used – a large set of indicators. The Sustainability and Resilience Benefits Analysis (SRBA) represents a specific and sophisticated approach to the use of indicators. This study will apply the SRBA approach to measure the Resilience Dividend component in times of non-disruption. A further value-adding tool is the International Disaster Database. At the end of this chapter the limits to this study's methodology will be discussed.

3.1 The Theory Behind the Study

This study hypothesizes that efforts to build resilience yield various types of benefits. Besides benefits in the form of saved lives, there are also financial, human, natural, physical, political, social, and economic benefits that can result from both disaster and non-disaster situations. To quantify them, we develop a simple model using the SuRe SmartScan, measurement indicators as well as some additional supporting tools.

As already mentioned, the objective of any inputs regarding resilience and sustainability is to obtain returns in the form of benefits. Here "inputs" are perceived in a broad sense and may comprise costs associated with education, planning, construction, labor, materials, and opportunity costs arising from the allocation of resources. An input represents an outflow, while benefits are inflows – both can be, but are not necessarily, of a monetary nature. Policymakers, investors and project developers are interested in how resilience expenditures compare to the expected benefits. However, an effective and simple measurement tool does not currently exist.

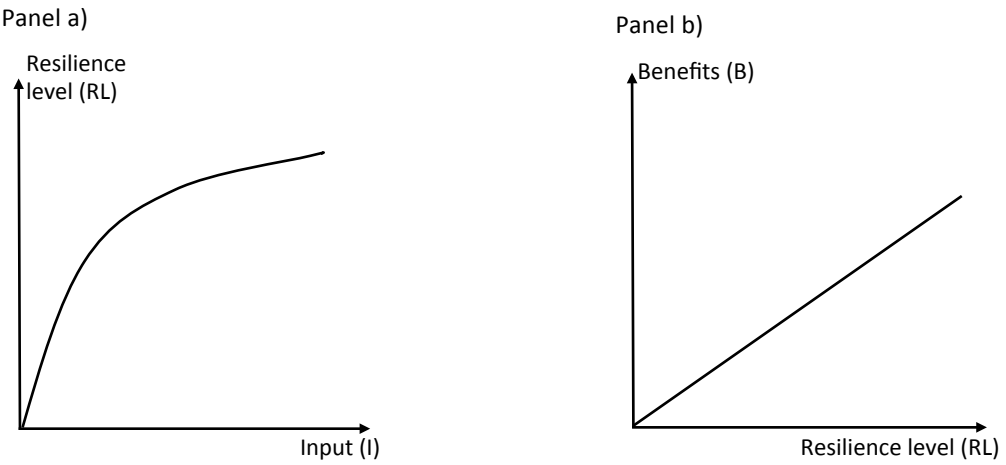
In our model, a certain amount of input (I) gives rise to a certain resilience level (RL). The resilience level corresponds to certain benefits (B). As already outlined, we perceive benefits as flows. Hence, the resilience level, itself a kind of a stock, yields a steady stream of benefits. We can describe these relationships using the following schematic functions:

$$\mathrm{RL} = f(\mathrm{I}) \qquad (1)$$
$$\mathrm{B} = f(\mathrm{RL}) \qquad (2)$$

3.1.1 Non-disaster scenario

Let us first consider the simple case of a situation without a disaster. Function (1) is shown in panel a) of Figure 2. It is reasonable to assume that, in situations with a low level of resilience, small inputs will have a large effect. The higher the resilience level, the higher the expense of additional improvements. To illustrate this with an example, in a community with a water shortage, constructing a pond is a relatively simple measure that will have quite a big impact on the community's resilience. Once this and other projects are realized, further measures, such as the installation of smart water meters, are more specific but yield comparatively less additional utility. Function (2) is shown in panel b): a higher level of resilience yields greater benefits. For simplicity, let us assume linearity between the benefits and the resilience level. Note that these curve assumptions are made simply to develop the model.

Figure 2 Relationship between resilience inputs, resilience level and benefits



Source: GIB Foundation

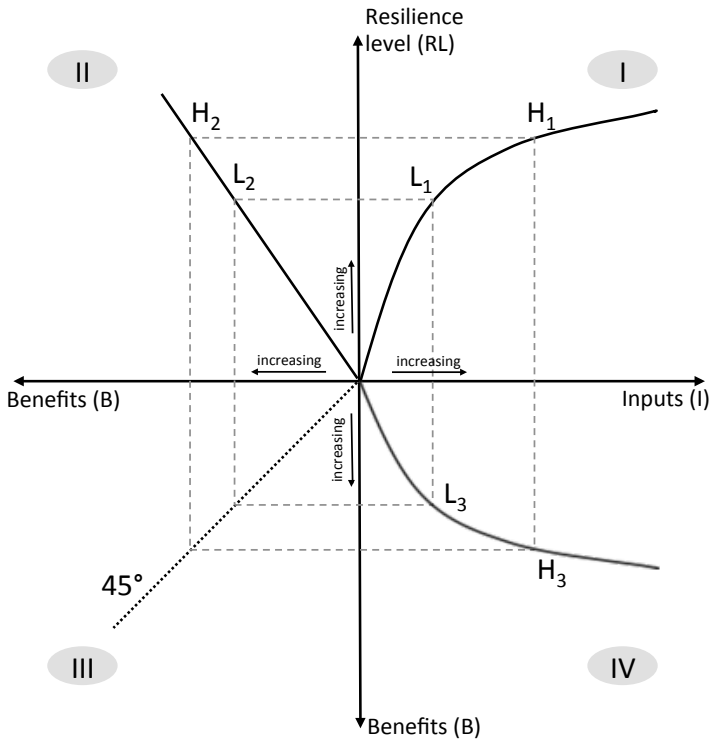
Given that they share a common axis (RL), the charts can be presented together. Quadrant I of Figure 3 is the same as panel a) in Figure 2. It shows that a high amount of resilience inputs leads to a high level of resilience (see point H_1). By translating this into Quadrant II of Figure 3, we obtain the corresponding benefits (point H_3). Quadrant III does not have any meaning in itself – it simply translates the flow of benefits into Quadrant IV by means of the 45° line. As a consequence, Quadrant IV reveals the relationship between inputs and benefits, which is the central aim of this study. Applying this same process to low inputs implies a low level of resilience and fewer benefits (see L_1, L_2, L_3, respectively).

One might ask why we do not just consider the relationship between investment and benefits directly, as shown in Quadrant IV. The answer is simple: we do not know this relationship automatically. It is only by going anti-clockwise through the four quadrants that we are able to carry out the cost-benefit analysis or, in more general terms, the input-output analysis. How does this work? The solution lies in the combination and application of the methods mentioned above. The central tool is the SuRe SmartScan.

Policymakers, project developers and investors want to know the optimal amount of inputs to achieve a desired level of resilience. Input expenditures are observable and quantifiable. However, we do not know the level of resilience that can be achieved with each input. Therefore, the SuRe SmartScan, derived indicators, and the SRBA are applied to the real-data check of a non-disaster scenario.[1] First, the SuRe SmartScan determines the resilience level of the project by assessing the project design characteristics, thereby connecting inputs to the resulting resilience. Function (1), exhibited in the first chart or in Quadrant I respectively, can thus be assessed. Second, the kind and magnitude of the benefits resulting from the resilience level are determined by using selected indicators and the SRBA. The latter measures, and thus quantifies, the benefits arising from inputs by comparing it with a case where there are no resilience inputs (project scenario vs. baseline scenario). By using the SuRe SmartScan, and by applying indicators as well as the SRBA, we are able to connect inputs and benefits and can thus determine the final relationship shown in Quadrant IV of Figure 3.

[1] These tools are introduced in more detail in the following sections.

Figure 3 Detecting the relationship between resilience inputs and benefits in the non-disaster case



Source: GIB Foundation

Note that the SuRe SmartScan not only allows the level of resilience to be assessed. It also indicates the kind of inputs that should be provided. One type of input may result in a larger resilience improvement than another. The SuRe SmartScan evaluates individual resilience measures, thereby enabling their comparison. In doing so, the SuRe SmartScan reveals the relationship between resilience and inputs, and allows this relationship to be optimized.

Why is it not possible simply to skip the SuRe SmartScan and measure the relationship between inputs and benefits directly using the SRBA? This is because, in the latter scenario, it would not be possible to locate the origin of the benefits. In our model, the SRBA quantifies the final outcome of the resilience inputs; it is not able to judge and value resilience measures and actions. As an example, an investor spends a certain amount of money and thereby achieves a reduction in GHG emissions of 5,000 tons, strongly reducing the project's dependence on fossil fuels. The SRBA is now able to account for the difference in emissions. But it cannot relate the difference to the action behind it if a SuRe SmartScan assessment has not been carried out.[2]

Moreover, the types and amounts of benefits are often unknown when an infrastructure project is being developed. Not every investment increases resilience by the same amount (or even at all). It is thus important to assess the level of resilience and its relation to resilience inputs. Once the resilience level is given, policymakers, project developers and investors will have a clear indication of the benefits associated with this respective resilience level. The real-world data check in the form of the project case analysis in the next chapter shows how this works and demonstrates that the tools can be applied to any project. Simply comparing random benefits with resilience expenditure does not provide a policymaker, project developer or investor with a tool indi-

[2] To be clear, the SRBA could do so but only in an extensive and data-rich application prior to project realization. In this study, the SRBA is employed after the project has been implemented.

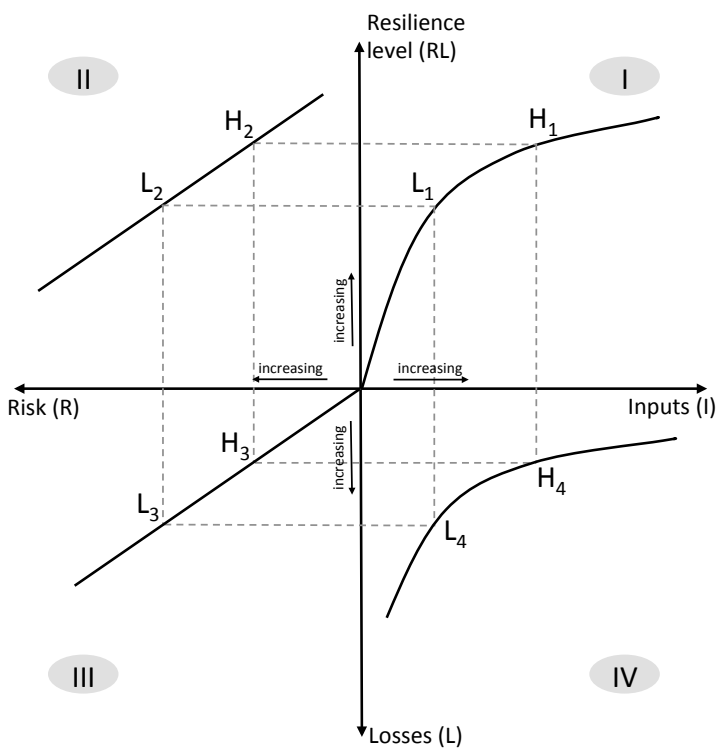
cating which measures to take. The SuRe SmartScan allows the resilience level of any infrastructure project to be determined.

3.1.2 Disaster scenario

This leads us to the next case: the analysis of a disaster situation. The high resilience of a project implies that it should also have higher benefits. However, the benefits in a disaster situation take the form of a reduction in loss. Losses of various kinds after a disaster are, in formal terms, negative benefits. This means that the benefits are highest when losses are minimized.

Given that disasters are unforeseeable, it is very difficult to predict their associated losses. This uncertainty can be accounted for by introducing a risk variable. The analogous but extended relationships are shown in Figure 4. The same high amount of input in resilience yields a corresponding resilience level (point H_1). The higher the resilience level, the lower the disaster risk (point H_2). The higher the disaster risk, the higher the losses incurred over a certain time period. This may be either due to the severity of potential disasters or to the high number of disaster events (or both of these factors). A lower risk therefore reduces losses after disasters (point H_3). This results in the inverse relationship between resilience inputs and disaster losses in Quadrant IV (point H_4). Again, lower inputs imply a lower level of resilience, higher disaster risk and higher losses over a given time period (points L_1, L_2, L_3 and L_4 respectively).

Figure 4 Detecting the relationship between resilience inputs and losses in the disaster case



Source: GIB Foundation

The measurement procedure is similar in part to the non-disaster case. The project developer knows the project costs, and the SuRe SmartScan measures the resilience level. To assess disaster risk, we use the International Disaster Database as a supporting tool (to be introduced below). Unlike before, the SRBA cannot be applied to this scenario. Even though losses have an analogous meaning to benefits ("negative benefits"), the

SRBA is unable to measure them because a baseline scenario[3] does not exist. For this reason, we choose selected indicators like the number of affected people – including fatalities, financial loss/impacts, changes in economic growth prospects and other potential social and environmental effects. In this way it becomes possible to relate the benefits, that is, reduced losses, to resilience inputs.

In conclusion, the SuRe SmartScan is a tool that can be applied by anyone involved with an infrastructure project. It shows the resilience level that can be achieved and gives an indication of the expected benefits. In doing so, it allows a cost-benefit analysis to be carried out in a simple and effective way. While financial and economic benefits can be measured in monetary terms, many environmental, social and governance (ESG) benefits cannot be monetized. Nevertheless, applying the SuRe SmartScan allows these ESG benefits to be estimated.

This study assesses the relationships plotted in the charts. In order to find the exact relationship between the resilience level and the benefits, it is important to test the above-mentioned theory with real data. Given that this study is not limited to financial and economic benefits, but also includes those which are much more difficult to quantify and cannot be expressed in monetary terms (ESG factors), it does not apply econometric tests or other statistical approaches. In addition, the amount of data available is limited for most projects.

3.2 SuRe® Standard

The SuRe® Standard is a non legally-binding, voluntary independent third party-certified standard developed through a multi-stakeholder approach incorporating inputs from a wide range of experts from industrialized and emerging countries. It aims to be compliant with the International Social and Environmental Accreditation and Labelling Alliance (ISEAL)[4] and integrates project level requirements derived from the most relevant international frameworks.

The SuRe® Standard is a rating standard that:

- Provides a **standardised approach** to implementing sustainability and resilience criteria (such as, for instance, GHG emissions reduction and resource efficiency) into all the different phases of an infrastructure project's life cycle, from planning and design to construction, operation and the decommissioning phase;
- Offers a **common definition of resilience and sustainability** for the public sector, the finance sector and project developers;
- Provides a platform for the **objective comparison** of projects, thereby improving project selection;
- Guides project developers to create **projects that are more attractive to financiers**.

The SuRe® Standard for Sustainable and Resilient Infrastructure has been developed based on the inputs of experts from the public sector, financing institutions, project developers, civil society and academia – spanning six continents. It is made up of a total of 65 criteria grouped into 14 themes which cover environmental, social and governance factors, and another two covering materiality assessment and reporting requirements. The Standard is being developed in accordance with ISEAL methodologies, and it creates a common language and understanding of sustainable and resilient infrastructure projects between the public sector, financial sector and project developers. Table 1 gives an overview of the SuRe® criteria.

[3] In this case, the baseline scenario would be the infrastructure project without any resilience investment after the disaster. However, this cannot be observed.

[4] For further information on ISEAL, see http://www.isealalliance.org

Table 1 Overview of SuRe® dimensions and themes

3 dimensions	14 themes	63 criteria	+2	
ENVIRONMENT	Climate	19	Materiality Assessment	Reporting
	Biodiversity and Ecosystems			
	Environmental Protection			
	Natural Resources			
	Land Use and Landscape			
SOCIAL	Human Rights	25		
	Labour Rights and Working Conditions			
	Customer Focus and Inclusiveness			
	Community Impacts			
	Socioeconomic Development			
GOVERNANCE	Management and Oversight	19		
	Sustainability and Resilience Management			
	Stakeholder Engagement			
	Transparency and Accountability			

Source: GIB Foundation

The SuRe® Standard can be applied throughout the different stages of a project's life cycle, enabling project improvements to be made from the early planning and concept design stages through to the construction, operation and decommissioning stages.

While the SuRe® Standard ensures that the infrastructure assessed will meet minimum requirements with regard to Environmental, Social and Governance (ESG) criteria, it also aims to highlight the true benefits of the infrastructure, and to promote infrastructure projects that provide solutions to sustainable development challenges (specifically targeted to the context of the project location). Projects certified with the SuRe® Standard will, in addition, contribute to achieving the objectives of the international policy agenda by addressing core environmental, social and governance aspects. For example, the SuRe® criteria take into consideration key international frameworks and conventions such as the Equator Principles, the International Finance Corporation (IFC) Performance Standards, the Sendai Framework for Disaster and Risk Reduction, the Convention on Biological Diversity (CBD) and the International Labour Organisation (ILO) Declaration on Fundamental Principles and Rights at Work. Furthermore, SuRe® is aligned with the 2030 Agenda for Sustainable Development, contributing in particular to Goal 9 "Build resilient infrastructure, promote sustainable industrialization and foster innovation", Goal 11 "Make cities inclusive, safe, resilient and sustainable", and to some extent Goal 6 "Ensure access to water and sanitation for all" and Goal 7 "Ensure access to affordable, reliable, sustainable and modern energy for all" (United Nations, 2015, pp. 20–24). Table 2 contains a list of the existing frameworks, conventions and standards that are taken into account in the SuRe® Standard. By applying the SuRe® Standard, a project developer, investor or policymaker can be sure that all these tools are automatically incorporated too.

Table 2 International agreements incorporated into the SuRe® Standard

ENVIRONMENT	Montreal Protocol on substances that deplete the ozone layer
	Convention on Biological Diversity
	Sendai Framework for Disaster and Risk Reduction
	IUCN Red list and Key Biodiversity Areas Standard
	Rotterdam Convention
	UNFCCC
	Stockholm Convention on Persistent Organic Pollutants
SOCIAL	UN Universal Declaration on Human Rights
	UN Guiding Principles on Business and Human Rights
	ILO Fundamental Principles and Rights at Work
	OECD BRIDGE Indicators (for gender equality)
GOVERNANCE + overarching frameworks	Sustainable Development Goals (SDGs)
	IFC Performance Standards
	The Equator Principles
	GRI Sustainability Reporting Standards
	FIDIC
	FATF National Money Laundering and Terrorist Financing Risk Assessment
	Transparency International Business Principles
	The OECD Guidelines for Multinational Enterprises
	The MNE (multinationals) Declaration (ILO)

Source: GIB Foundation

Following the launch of SuRe® at COP21 in December 2015, the standard entered its pilot phase. During this phase, SuRe® is being applied to real projects, with a view to improving project design and simultaneously refining the standard. This refinement will help to align the standard more closely with local contexts, thereby providing maximum benefits and utility to infrastructure projects and the industries that rely upon them.

Currently, GIB is piloting SuRe® on a number of infrastructure projects in Central Europe, Eastern Europe, China, India and the Asia-Pacific region. In each region, GIB has looked at how the SuRe® criteria can be used to enhance project design and/or operation and to demonstrate these enhancements to stakeholders and potential financiers. For example, in India, GIB has assessed a rail company to understand and improve their readiness for anticipated climate change impacts such as flooding and heat waves, which can cause severe damage to rail infrastructure. GIB has also worked with a range of utility and waste services on issues such as planning post-decommissioning and improving conditions for workers. In Eastern Europe and Asia, GIB has worked with projects to better understand and improve resource efficiency in the construction phase, for example by identifying recycled and recyclable construction materials to decrease the project's effective material consumption now and in the future. GIB has also worked to enhance transparency and stakeholder involvement, with a view to decreasing the risk of corruption and to ensure infrastructure adequacy in the eyes of stakeholders.

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Box III

Ensuring the credibility of the tool: governance of the SuRe® Standard

To guarantee transparent and due process safeguards as well as professional independence from other GIB activities, the SuRe® Standard development is governed by two main bodies: the SuRe® Standard Committee and the SuRe® Stakeholder Council.

The SuRe® Standard Committee decides on SuRe®'s strategy, overall approach and content, based on their diverse experience and insights. Committee members actively provide input on the standard's content, criteria and program, if necessary by leading thematic working groups and sub-committees. The Committee brings together expert knowledge from many different fields. For instance, there are members from the European Investment Bank (EIB), WWF Switzerland and Transparency International.

The Stakeholder Council is a formal multi-stakeholder forum. It provides feedback and recommendations on SuRe® to ensure the relevance of the standard to the relevant groups of stakeholders and regions of the world. Council members include, among others, representatives of the OECD, UN, development agencies and local governments from around the world, and NGOs. Full lists of the current members of both the SuRe® Standard Committee and the Stakeholder Council can be found in the Appendix.

The frameworks, conventions and standards in Table 2 are the result of years of multi-stakeholder negotiations. They are often well understood at the national level, but not translated well at the project level, as they are rather difficult for project designers and planners to apply. Therefore, in partnership with the SuRe® Standard Committee and the Stakeholder Council, the elements of each framework were brought down to the project level by putting them into a format that is easily understood by project developers.

3.2.1 SuRe SmartScan

The SuRe SmartScan is an infrastructure due diligence tool that provides a quick assessment of an infrastructure project against resilience and sustainability criteria covering Environmental, Social and Governance issues. Like "Credit SuRe" and "SuRe Underwriting"[5] (see Chapter 6), the SuRe SmartScan has been developed based on the SuRe® Standard for Sustainable and Resilient Infrastructure. However, it provides a more simplified approach than a full certification under SuRe®, and can be used by stakeholders to carry out a first self-assessment of a project. Three specific aspects describe the characteristics of the SuRe SmartScan and illustrate its credibility:

- It is based on the SuRe® Standard, which itself is based on international frameworks, and a multi-stakeholder 'filter' which enabled the selection of the most relevant criteria;

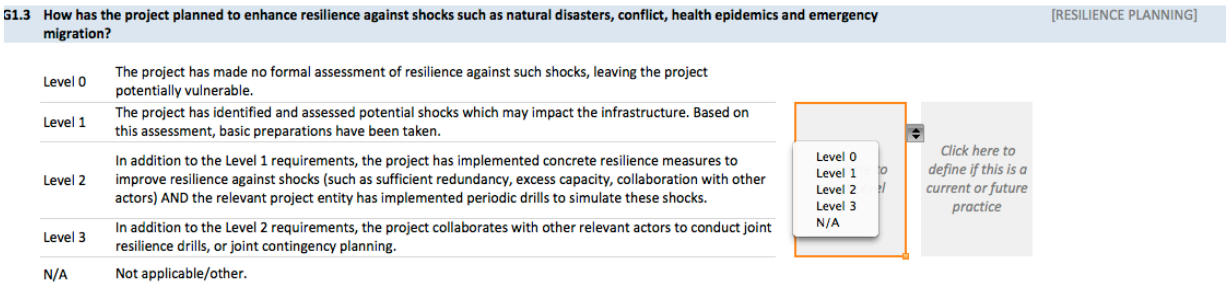
[5] Since 70 to 90 percent of all infrastructure projects are debt-financed, a tool serving the needs of credit rating agencies (CRA) is needed. GIB's "Credit SuRe" blueprint might serve as a basis for future tools, especially since it has been developed with a commercial CRA partner. Additionally, the GIB envisioned "SuRe Underwriting" tool would make sense. How to assess resilience and sustainability related infrastructure risks? How to mitigate them? What resilience and sustainability related risks should be finally taken on board by an insurance company? These questions express the concerns of an increasing number of insurance companies – especially since they often play a double role as insurers of and investors in infrastructure projects.

- It is based on the GIB Grading (SuRe® Standard predecessor) experiences, developed together with utility companies, and used on over 150 infrastructure projects around the world;
- It comprises a selection of SuRe® Standard criteria, which are practical for a self-assessment irrespective of the previous experience of the assessment taker.

The SuRe SmartScan consists of 75 questions, divided into 14 themes, and gives an aggregated index value per theme. Furthermore, it defines two benchmarks that allow for an assessment of the resilience and sustainability performance level of an infrastructure project: the lower benchmark is the 'reasonable benchmark', below which sustainability and resilience are largely absent; the upper layer is the 'commendable benchmark', above which the project can be considered excellent. Between the benchmarks, sustainability and resilience are largely accounted for, but may be further improved.

The project manager answers 75 questions by choosing a certain level for each (see Figure 5 below). Depending on the degree of engagement, the answer may be level zero, one, two or three respectively. Level zero applies if the project manager has never been, or has almost never been, concerned with the corresponding criterion. The highest level is achieved if the highest norms and standards of the specific field are applied. If a specific criterion is not mentioned at all in the data source, the reason may be either because it has simply not been accounted for or is not applicable (N/A) due to the project's specific character. In this assessment, we only indicated a level 0 or N/A if the data provided a clear answer to this question. Furthermore, topics like water, air, stakeholder engagement etc. might be found in various themes in the E, S, or G (Environment, Social or Governance) analysis because of their multi-faceted implications (e.g. stakeholder engagement might be analyzed from a G and an S perspective).

Figure 5 SuRe SmartScan example question



G1.3 How has the project planned to enhance resilience against shocks such as natural disasters, conflict, health epidemics and emergency migration? [RESILIENCE PLANNING]

Level 0	The project has made no formal assessment of resilience against such shocks, leaving the project potentially vulnerable.
Level 1	The project has identified and assessed potential shocks which may impact the infrastructure. Based on this assessment, basic preparations have been taken.
Level 2	In addition to the Level 1 requirements, the project has implemented concrete resilience measures to improve resilience against shocks (such as sufficient redundancy, excess capacity, collaboration with other actors) AND the relevant project entity has implemented periodic drills to simulate these shocks.
Level 3	In addition to the Level 2 requirements, the project collaborates with other relevant actors to conduct joint resilience drills, or joint contingency planning.
N/A	Not applicable/other.

Source: GIB Foundation

Furthermore, the SuRe SmartScan offers cities and project owners a practical way to rapidly tap into international best practice and to efficiently flag risks and opportunities for improvement in their projects. For instance, the SuRe SmartScan addresses the question of whether or not an evacuation plan exists. Depending on the type of disasters the project area is prone to, such a plan naturally considers different elements. In an area prone to cyclones, for example, the provision of a sufficient number of reliable shelters may be an element of the plan and hence decisive to raise resilience. This prepares projects for the scrutiny of potential financiers, who increasingly focus on ESG criteria when assessing projects.

Box IV

Delhi-Mumbai industrial corridor project: SuRe SmartScan assessment

The SuRe SmartScan has been successfully applied to an infrastructure development within the Delhi-Mumbai Industrial Corridor Project, India. The Industrial Corridor is one of the world's largest infrastructure projects and aims to accelerate industrial activity across seven Indian states. In assessing one of the developments along the corridor, the SuRe SmartScan was used to identify design improvements as well as to demonstrate areas in which the development was already performing very well, in a format that matches the priorities of multilateral investors. This information was then used to inform the management level of the overall project, with the aim of generating resilience and sustainability improvements in future developments along the corridor (please also refer to the outlook in Chapter 6).

3.2.2 What is not the target of the SuRe® Standard and the SuRe SmartScan?

It is essential to remember that both the SuRe® Standard and the SuRe SmartScan focus on the micro level, that is, on individual projects instead of cities or regions. While many sustainability and resilience criteria apply to all levels, there are some differences in the assessment depending on which level is addressed. A resilience analysis on the meso or city level focuses on the risk for the city population and the city infrastructure like traffic systems or the electrical power supply. Relevant questions include: Does the traffic system still work when an earthquake hits the city, and can it be used to evacuate people? Is there enough electricity to maintain health care? Is the city infrastructure efficient in order to minimize GHG emissions? Hence, on the city level, network effects and dynamic interactions in a complex system are emphasized.

Such issues are not completely ignored on the micro level of the infrastructure project, and they are also addressed in the SuRe® SmartScan. But in the latter, the focus is more on the project details. We want to know whether an infrastructure project is able to keep up its services even when the rest of city life breaks down in the face of an extreme disaster. Moreover, the SuRe SmartScan analyses the direct consequences of a single project on the environment, society and governance.

Both, the meso and micro approaches are important and complementary in many aspects. Their application can each make a contribution to improved resilience and sustainability. However, the micro level approach has an important advantage: while a city level concept is only feasible for the local government administration, individual projects can basically be planned and realized by any stakeholder. Hence, the SuRe SmartScan is a tool for a broad spectrum of potential users who are interested in making a contribution to resilience and sustainability. This makes the tool highly practice oriented.

The Mathbaria case study outlined below may seem to contradict this argument because it is part of the "Coastal Towns Infrastructure Improvement Project". However, the focus of the project is compatible with the SuRe SmartScan because it consists of some subprojects within the city. As a result, the eventual emphasis is on concrete infrastructure projects.

Naturally, the micro level approach requires some concessions. Several macro and meso level questions are only partially addressed. For instance, the issue of migration is treated with respect to an infrastructure project: does the project require a resettlement plan or not? Moreover, resilience measures like the planting of mangroves in Bangladesh may have a crucial impact on people's propensity to migrate (see the Mathbaria case study in this respect). However, the macro perspective on the migration issue cannot be covered: what happens if there are large population movements following a disaster? As an example, a drought may give rise to whole communities fleeing the countryside to go to cities. Since infrastructure projects are usually fixed in a

certain place, migration can only be grasped from the project's specific perspective – buildings do not flee. A similar topic is income distribution. The SuRe SmartScan contains a question which focuses on the wages and working conditions in the project being assessed. This, of course, has only a limited impact on the rest of the economy. But the SuRe SmartScan, in its current version, does not target the question of how the newly achieved sustainability and resilience levels affect income distribution in the society as a whole.

3.3 Indicators

In this study, indicators are used to help confirm the existence of a Resilience Dividend from an infrastructure project (micro level) or a city as a whole (macro/meso level) in case of disasters and irrespective of disasters. Moreover, these indicators also help to validate the SuRe SmartScan assessed resilience level of a specific infrastructure project.

The next few paragraphs explain how and from where these indicators are derived, how indicators help to confirm the resilience level of the SuRe SmartScan, how this study combines the SuRe SmartScan and the indicators to measure the Resilience Dividend, how the resilience indicators can be verified, and how this approach can be adopted and adjusted for future use and to measure the Resilience Dividend on the infrastructure project level or even on the city level.

3.3.1 Background on the sources of the indicators and other factors

The indicators were mainly derived from the following sources:

- United Nations International Strategy for Disaster Reduction (UNISDR; 2008)
- Asian Cities Climate Change Resilience Network (ACCCRN; Tyler et al., 2014)
- Organisation for Economic Co-operation and Development (OECD; 2014)
- Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ; 2014)
- Arup, RPA and Siemens (2013)
- Chakrabarti (2013)
- Oxfam (2015)
- Institute for Housing and Urban Development Studies Rotterdam (IHS)

and other research carried out by the GIB study team. Most of the aforementioned sources refer to macro /meso level indicators. For this study, however, the indicators have been adjusted in order to apply them to an infrastructure project context on the micro level. It is also important to note that the indicators vary according to the type (sector) of infrastructure project. For example, a road in Manila does not have the same indicators as an airport in Quito, nor does a road in Nigeria necessarily have the same indicators as a road in Manila. Moreover, there is also a difference between indicators after a disaster and indicators without a disaster.

The post-disaster indicators of this study have been adopted from the OECD (2014) guidelines on resilience system analysis (see Section 2.2). The indicators are divided into the following six categories outlined in bold. As an illustration, some post-disaster indicator examples are provided for an expressway in Manila.

4) **Financial Dividend** – *Was the infrastructure project covered by a natural hazard insurance?*
   → Amount of money saved

5) **Human Dividend** – *How well was the management/staff prepared for emergencies and disasters?*
   → Number of fatalities and injuries avoided

6) **Natural Dividend** – *How was the use of wetlands planned in order to reduce flooding risks?*
   → Size of natural area not negatively affected

7) **Physical Dividend** – *How long was the road closed due to a typhoon?*
   → Uninterrupted access to critical infrastructure

8) **Political Dividend** – *Was there transparency and accountability in the aftermath of the disaster?*
   → Were the decisions fair and transparent?

9) **Social Dividend** – *How was the access to basic needs, e.g. food, water, finances, health care etc.?*
   → Uninterrupted access to goods and services

The second set of indicators refers to a scenario without a disaster, which differentiates between four categories: environmental, social, governance, and economic indicators. These four categories were adjusted from IHS' Sustainability and Resilience Benefit Assessment (SRBA) framework and subsequently introduced. The indicators provide information on the reduction of air pollution, the reduction of traffic congestion, the cooperation between multiple stakeholders, or the reduction of maintenance costs.

It should be noted that some indicators might be assigned to more than one of these six (disaster case) and four (non-disaster case) categories. For example, access to health services might be qualified as both a human dividend and a social dividend. In both cases, we refer to the corresponding definitions of the OECD (2014) and the SRBA.

As regards any other resilience approach and analysis, the quality of the indicators is only as good as:

- the diversified knowledge and expertise of the derived sources;
- the quality and availability of relevant data; and
- the quality of the underlying contextual or risk analysis (OECD, 2014)

3.3.2 How the indicators help to confirm the resilience level of the SuRe SmartScan

In this study, the indicators are not only used to assess the Resilience Dividend, they are also used to help confirm the assessed resilience level of the respective SuRe SmartScans. A specific indicator indicates a specific outcome after a disaster, which can then be compared with the indicated resilience level of the SuRe SmartScan. In doing so, this study compares the SuRe SmartScan findings that represent the resilience level of an infrastructure project at a certain point in time (a "snapshot") with the outcome of how this infrastructure performed during a disaster. It acts as a first step in the necessary ongoing validation of snapshot findings in order to eventually arrive at correlations between assessed resilience levels prior to a disaster and post-disaster outcomes.

For example, a road is flooded during a typhoon and is closed for two days: "closed roads due to flooding" is a road infrastructure specific indicator. During the initial snapshot assessment of resilience levels, data demonstrates that the re-routing of storm water during construction made the road more vulnerable to floods – which is eventually what happened in this example. The present study would then compare these findings with the SuRe SmartScan. One of the 75 SuRe SmartScan questions focuses on storm water, and would indicate that the infrastructure project did not assess storm water in their environment and impact assessment. As a result, if the management of the infrastructure company had included storm water in their assessment, they would have calculated the risk of storm water flooding in their project. Hence, the flooding of the road and its closure for two days could have been prevented.

This is how this study tries to confirm the indicated resilience level of the SuRe SmartScan with the previously explained indicators. Please refer to the Theory behind the study in Section 3.4 for further information.

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3.3.3 Our approach to the Resilience Dividend study: the combination of the SuRe SmartScan and the indicators

Why is it important to do a resilience analysis, including a post-disaster analysis? According to the OECD (2014), a resilience systems analysis will provide key stakeholders with:

1) A shared view of the risk landscape that people face;
2) An understanding of the broader system that people need for their overall well-being;
3) An analysis of how the risk landscape affects the key components of the well-being system – which components are resilient, which are not, and why;
4) A shared understanding of power dynamics, and how the use or misuse of power helps or hinders people's access to the assets they need to cope with shocks; and
5) Based on all of the above, a shared vision of what needs to be done to boost resilience in the system, and how to integrate these aspects into policies, strategies and development efforts at every layer of society.

The combination of the SuRe SmartScan and the indicators (with and without a disaster) forms the central framework of this study. As mentioned above, the SuRe SmartScan is important to have a snapshot of the situation in the case studies at a given point of time. In turn, indicators will then assess resilience and ESG topics especially after disasters have taken place.

The combination of these two approaches is crucial because one approach alone will not reveal the whole picture. The study uses the SuRe SmartScan to assess an infrastructure project for its resilience and sustainability level as well as indicators to be used after the assessment that try to confirm the resilience level as previously explained. By analyzing case studies and combining the two approaches, this study marks the first steps towards indicating the Resilience Dividend in the case of a disaster and without.

Box V

Snapshot and assessment over time

An Overseas Development Institute (ODI) mandated report written by Schipper & Langston (2015) explored resilience measurement frameworks with a specific focus on indicators. The study analysed 17 indicator resilience frameworks and provided ways to increase understanding of them. The authors (2015) identified the following key issues for resilience and indicators moving forward:

1) Each framework is strongly influenced by its conceptual entry point, making a comparison only partially possible and justifying the development of further frameworks;
2) There is a clear gap between the theory on resilience and the way in which the indicators focus on well-being and general development factors; and
3) Indicators may not always provide a complete picture of resilience (ibid.).

GIB's approach in this study contributes to discussions on how to solve the above issues. It starts by focusing on the entry point of a multi-stakeholder approach in combination with the leading resilience and sustainability standards (see section 3.2). In tackling the last two issues raised by Schipper & Langston (2015), the approach provides a complete picture of the resilience level assessment and its combination with the sector- specific infrastructure indicators.

***Box V** continued*

Additionally to the ODI paper, recent discussions at an ISEAL workshop in London on Monitoring and Evaluation (M&E) systems revealed that the combination of compliance indicators and M&E indicators is widely regarded as the best way to measure impacts. Compliance indicators are used to assess whether specific criteria have been applied with regard to an overall standard *at a certain point in time*. On the other hand, M&E indicators are used to measure a change *over time*. Additionally, they measure the effect of compliance on a specific criterion. This idea of ISEAL on indicators corresponds exactly with the Resilience Dividend approach of this study: Using the SuRe SmartScan as a snapshot assessment of resilience levels (a "compliance indicator") and sector/project-specific indicators to subsequently validate the findings over time ("M&E indicators").

3.4 Additional Contributing Tools and Sources

3.4.1 SRBA – Sustainability and Resilience Benefit Assessment

The Sustainability and Resilience Benefits Assessment (SRBA) is a methodology that measures the impact of sustainability and resilience in infrastructure projects and serves as the main source for the above-mentioned indicators in times without disasters (please refer to section 3.2.2). It measures sustainability and resilience benefits by comparing the project to the status quo or to some hypothetic optimum (baseline scenario). The measurement criteria cover sustainability categories (environmental, social, governance, and economic) as well as other aspects (risk reduction, climate change, efficiency of resources, learning, institutional enhancement). The selection of criteria depends on local conditions as well as on their applicability in the respective case. The resulting benefits may be scrutinized on different levels (individual, local community, city, global). The benefits can be weighted if desired/needed. The Institute for Housing and Urban Development Studies (IHS)[6] developed this tool in a mandate from the World Bank Group.

3.4.2 International Disaster Database

The present study uses disaster data for the specific regions from the Centre for Research on the Epidemiology of Disasters (CRED). This database "is a global database on natural and technological disasters, containing essential core data on the occurrence and effects of more than 21,000 disasters in the world, from 1900 to present" (CRED, 2017). The disaster database is updated and maintained by CRED at the School of Public Health of the Université catholique de Louvain, Brussels, Belgium. According to CRED (2017), the main goals "are to assist humanitarian action at both national and international levels; to rationalize decision making for disaster preparedness; and to provide an objective basis for vulnerability assessment and priority setting". The database comprises all disasters since 1900, which fulfil at least one of the following criteria:

- 10 or more people dead;
- 100 or more people affected;
- The declaration of a state of emergency;
- A call for international assistance (ibid.).

[6] For further details, see https://www.ihs.nl/about_ihs/introduction/

The database acquires the information from various sources, including UN agencies, non-governmental organizations, insurance companies, research institutes and press agencies. According to CRED (2017) "priority is given to data from UN agencies, governments, and the International Federation of Red Cross and Red Crescent Societies. This prioritization is not only a reflection of the quality or value of the data, it also reflects the fact that most reporting sources do not cover all disasters or have political limitations that could affect the figures". CRED updates, reviews and consolidates daily so that there are no inconsistencies or redundant/incomplete information.

3.5 Limitations of this Study

The theoretical field of this study is clearly identified in the previous section. It indicates which sustainability and resilience efforts should be made in order to reach the targeted outcome in the most effective and efficient way. However, there are limitations that have to be addressed. They do not make the achievement of results impossible, but indicate the need for future research.

The first issue to point out is the existing limitations to quantification. Quantifying the Resilience Dividend is basically possible. But this does not necessarily mean that the result of this study is a single numerical value. As outlined at the beginning, and as will be seen in the individual project cases, this study identifies two Resilience Dividend components depending on whether or not a disruption occurs. In the case of a disaster, six types of capital (financial, human, natural, physical, political, and social dividend) are considered and hence there are six dividends that combine to form the total Resilience Dividend in the disaster case. In the non-disaster case, the SRBA distinguishes the elements of the Resilience Dividend component further (environmental, social, economic and institutional benefits).

Independent of this study's specific framework, and irrespective of which concept of the Resilience Dividend is chosen, it is obvious that resilience is a multidimensional term. While its financial dividend may be estimated in monetary terms, the human dividend is concerned with the number of saved lives, and the environmental dividend is, among other things, about the amount of greenhouse gas (GHG) emissions. These three issues are just examples, and each subcomponent has many more topics and hence many more terms of measurement. Achieving a single number as the final result would require a merger of Dollar units with units of human lives, carbon emissions etc. To achieve this, very subjective calculations would be required (for instance estimating the value of a human life what per se is an ethical question) and considerable assumptions would have to be made. As a consequence, the reliability of the final result would be doubtful. Whether the result has a unit term, and which one it may be, therefore becomes rather arbitrary.

This substantial shortcoming of empirical methods is the reason why many estimates of resilience focus on one specific aspect. Measuring the financial return of resilience efforts usually means that only the financial dividend and, at the most, the economic dividend are accounted for. Environmental, social, physical, governance and political aspects are ignored. This does not mean that measuring the financial dividend of resilience is useless. But it reveals a trade-off: either a specific component of the Resilience Dividend is estimated in a quantitative way, while most other aspects are ignored, or the Resilience Dividend is investigated in all its dimensions. The latter approach provides a more complete picture, but hampers quantification in the form of a single value. The SuRe® Standard and the SuRe SmartScan are oriented towards the more comprehensive approach. There are several reasons for this. First, a project developer needs an overall perspective of the effects of his resilience and sustainability efforts rather than just a fraction of it. Second, this approach does not impede any quantification at all. According to the data available, it is possible to quantify the number of human lives saved as well as the amount of GHG emissions or even the impacts on biodiversity. However, these estimates are not merged, and the final result remains multidimensional.

The second limitation of this study is the data available. As mentioned, all aspects of the Resilience Dividend may, in principle, be quantified in detail depending on the data available. Unfortunately, the data required has only partially been collected. There is usually workable information on the infrastructure projects' environmental, social and governance engagement, while financial flows are often missing. It is much more difficult to find out how a project will perform after a disaster. Data on the number of fatalities and affected people is available, but only on an aggregated level in most cases. In the future, we need more quantifiable data on how a project will perform during a disruption, how many lives could be saved thanks to its ongoing services for the population, and what financial and economic gains can arise from this. Moreover, additional details on the benefits in non-disruption times would be helpful. Once this data is collected, the core competence of the SuRe SmartScan will be to relate the resilience benefits to the resilience inputs and to make sense of the relationship in between. The results of this study will clearly indicate the existence of the Resilience Dividend by means of the SuRe SmartScan. However, future research is needed in order to make further steps towards a clearly measurable Resilience Dividend.

4 Case Studies

This chapter assesses specific infrastructure projects in the cities of Manila (Philippines), Quito (Ecuador), Port-au-Prince (Haiti) and the coastal town of Mathbaria (Bangladesh). The infrastructure projects are two expressways in Manila, an international airport in Quito, an international seaport in Port-au-Prince, and a resilience improvement city-project in Mathbaria. The goal is to present the respective Resilience Dividend for each specific infrastructure project. While it is possible to compare two projects of the same sector in Manila, there are only data of one project in each of the other case studies. Therefore, comparison is made with the situation before project realization or with the old project of the same character that has been replaced by the new one. Usually, data for such comparisons exist but they are insufficient to conduct a full second SuRe SmartScan assessment. For this reason, specific procedures are explained in the respective case studies.

The infrastructure cases are assessed in the following order: 1) Manila, 2) Mathbaria, 3) Port-au-Prince, and 4) Quito. Each case consists of the following:

1) An **introduction** that provides background information on the macro/meso level, the infrastructure project itself (micro level), and the data used for the assessment;
2) The application of the SuRe SmartScan on the respective infrastructure project in order to determine **the resilience level assessment**;
3) Selection of specific disaster events and a subsequent **post-disaster assessment** of the infrastructure project, with the help of the indicators and the international disaster database;
4) A projection of the **Resilience Dividend** in the event of a disaster (avoided losses) and without a disaster (additional benefits) with the help of indicators;
5) The **interpretation of the Resilience Dividend**, summing up all the findings of the above-mentioned steps.

The overall Resilience Dividend interpretation across all four cases, the lessons learned, and the limitations of this study are subsequently presented in Chapter 5.

4.1 Manila

4.1.1 Background

Macro and Meso Level

The Philippines have a strong agricultural sector, thanks to the tropical climate, heavy rainfall and the naturally fertile volcanic soil. The agricultural sector employs over a third of the population, and the manufacturing sector is concentrated in the metropolitan area of Manila (The Columbia Electronic Encyclopedia, 2017).

According to the INFORM[7] country risk profile (2017), the Philippines have the 4th highest hazard and exposure to natural disasters in the world. This is because of the high exposure to earthquakes, tropical cyclones and tsunamis. In the overall risk index, it is ranked 52nd. However, as regards the lack of coping capacity, the Philippines are only ranked 107th in the world, which means that their coping capacity is relatively high due to,

[7] INFORM is a composite indicator that identifies 190 countries at risk of humanitarian crisis and disaster that would overwhelm national response capacity. The INFORM index supports a proactive crisis and disaster management framework. It is based on risk concepts published in scientific literature and envisages three dimensions of risk: Hazards & Exposure, Vulnerability and Lack of Coping Capacity. 53 core indicators represent the three dimensions (INFORM, 2017).

among others, DRR plans and the quality of physical infrastructure. The amount of uprooted people and the inequality are the main risks in terms of vulnerability.

Going a step further by considering the city level, the Lloyd's City Risk Index[8] (2015) shows that the capital, Manila, has moderately high economic growth. However, GDP@Risk, that is, the share of GDP that is threatened by potential disruptions of various kinds, is extremely high. The expected disasters between 2015 and 2025 may destroy 50% of the capital's economic output. As a second extreme, Table 3 shows that about 90% of Manila's risk of disruptions is due to natural disasters. In particular, wind storms are predicted to cause severe damage. In 2013, the Philippines experienced more than twenty wind storms, among which the severe typhoon Haiyan is still remembered.

- Average GDP growth rate: 3.46%
- Average annual GDP: USD 201.08bn
- Total GDP@Risk: USD 101.09bn
- Share of Average annual GDP: 50.28%

Source: Lloyd's (2015)

Table 3 GDP@Risk in Manila

Threat	GDP@Risk	Share or Total GDP@Risk
Wind storm	USD 60.66bn	60.01%
Earthquake	USD 13.29bn	13.15%
Volcano	USD 5.81bn	5.74%
Flood	USD 5.46bn	5.40%
Market crash	USD 4.79bn	4.74%
Human pandemic	USD 3.49bn	3.45%
Oil price shock	USD 2.39bn	2.36%
Drought	USD 1.86bn	1.84%
Terrorism	USD 0.76bn	0.75%
Sovereign default	USD 0.71bn	0.71%

Source: Lloyd's (2015)

Micro Level: Expressways

South Luzon Expressway (SLEX)

The South Luzon Expressway (SLEX) connects Manila to the South Luzon Batangas province. The project consisted of the rehabilitation, construction and extension of this expressway. In particular, it involved the rehabilitation and extension of the 1.2km Alabang viaduct and the 27.3km expressway between Alabang and Calamba, as well as the construction of a new 7.6km expressway section from Calamba to Santo Tomas. The two new lanes enlarged the existing capacity of the expressway. Construction began in 2006 and was completed in 2010, when the expressway started operating. The project company is the South Luzon Tollway Corporation, which is owned by the Philippine National Construction Corporation (PNCC) and by MTD Manila Expressways, Inc. (MTDME). The International Finance Group (IFC) contributed USD 50 million to the project, which had a total budget of USD 214.6 million.

[8] Lloyd's City Risk Index 2015-2025 analyses the potential impact on the economic output (GDP@Risk) of 301 of the world's major cities from 18 man-made and natural threats. It shows how governments, businesses and communities are highly exposed to systemic, catastrophic shocks and could do more to mitigate risk and improve resilience (Lloyd's, 2015).

North Luzon Expressway (NLEX)

"In the early 1990s, the Government of the Philippines recognized the need to rehabilitate the 30-year-old North Luzon Expressway (NLEX). The state-owned Philippine National Construction Corporation (PNCC) has had the franchise for the toll road since 1977. With faster economic growth, traffic volumes were increasing and NLEX was congested. This was exacerbated by frequent flooding and the road's poor and potholed surface. PNCC lacked the financial resources to operate, maintain, and expand the toll road to meet the projected increase in traffic. In 1995, PNCC assigned its rights and interests under its franchise to construct, operate, and maintain toll facilities on NLEX to Manila North Tollways Corporation (MNTC). MNTC was incorporated under a joint-venture agreement between the First Philippine Infrastructure Development Corporation (FPIDC) and PNCC for rehabilitation of the NLEX, with FPIDC owning 60% of the equity and PNCC 40%. FPIDC was established by Benpres Holdings Corporation (BHC) to enter into contracts with the public sector.

On 26 October 2000, the Board of Directors of the Asian Development Bank (ADB) approved a direct loan to MNTC of up to USD45 million without government guarantee and a complementary loan of USD25 million (all from ADB's ordinary capital resources) to rehabilitate, expand and operate 83.7 kilometers (km) of NLEX under the North Luzon Expressway Rehabilitation and Expansion Project. It involved the construction and/or rehabilitation of 14 interchanges, 24 bridges, and 31 overpasses from Manila (Balintawak) to the Santa Ines exit providing access to the Clark Special Economic Zone. Rehabilitation of an 8.8 km expressway in the Subic Special Economic Zone, constructed in 1996, was included as part of the project" (ADB, 2011, p. 1).

Used data (see references for full citation)

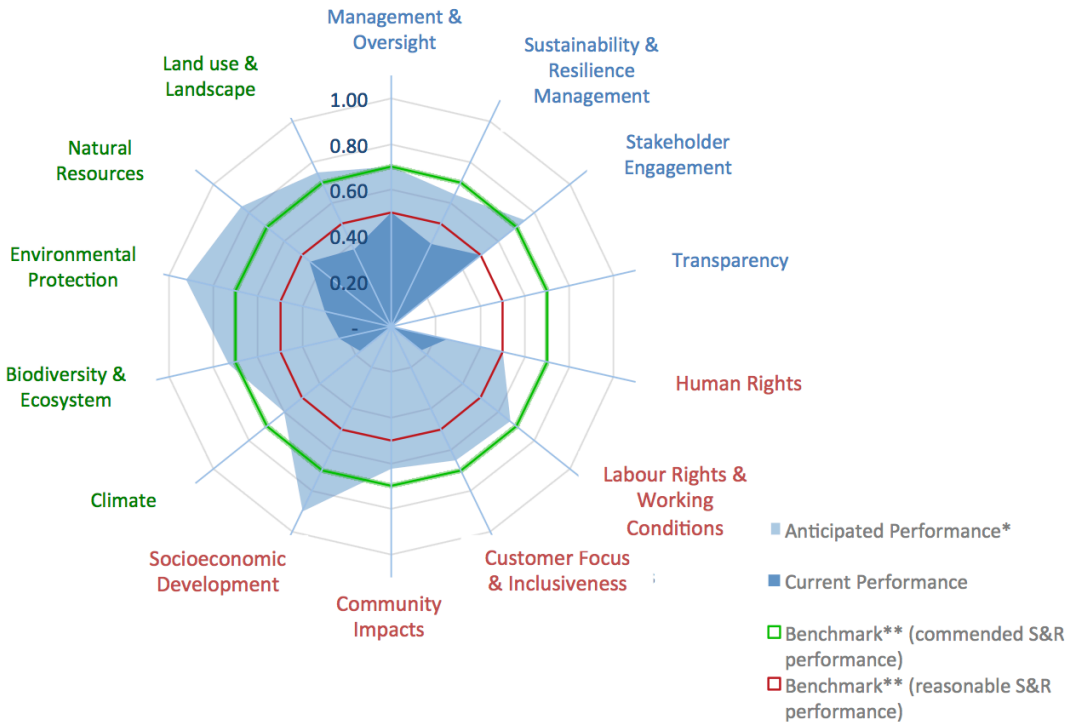
- Environmental Impact Assessments (retrieved from ADB, JICA, or IFC)
- Performance Evaluation Reports (retrieved from ADB, JICA, IFC)
- Various academic articles
- Online news articles
- Various stakeholder websites

4.1.2 Resilience level assessment

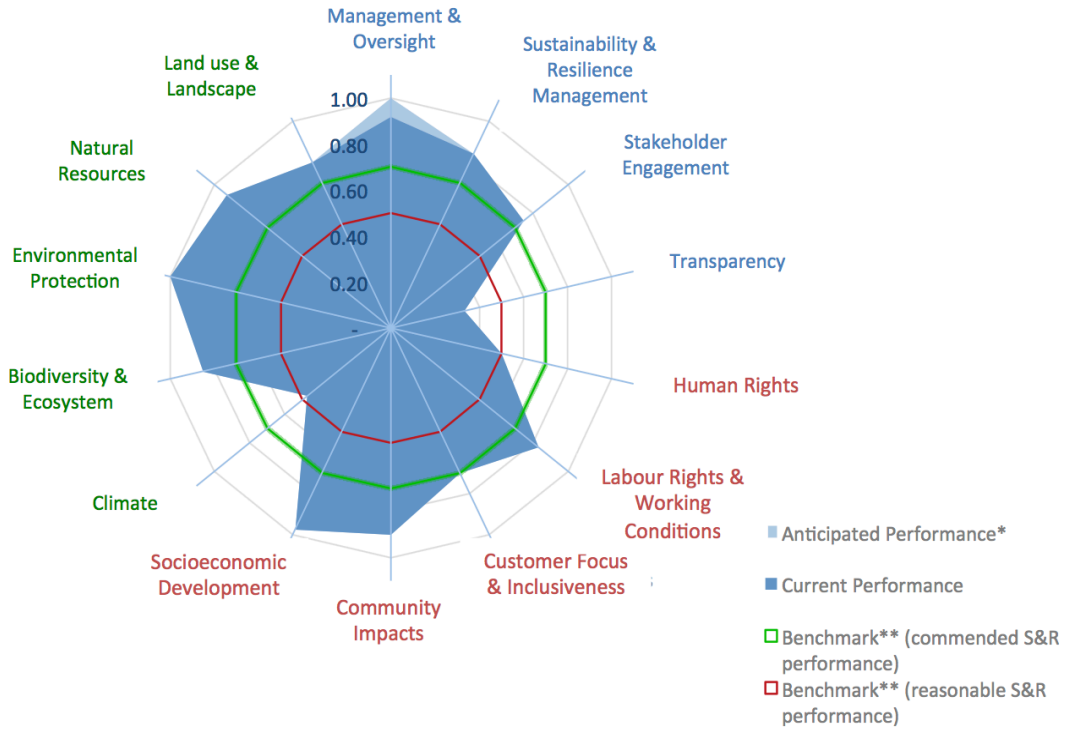
The SuRe SmartScan reveals the following project characteristics. The overall rating for the NLEX is quite high, and is better than for the SLEX. For instance, the NLEX is partially constructed on ground-saving stilts that are suggested to protect the toll road against floods. Moreover, the operating company of the NLEX features a rather outstanding environmental engagement. At the same time, it has to be said that the SuRe SmartScan of the SLEX is respectable, too. It has to be noted that the SLEX assessment was mainly based on ex-ante data, while the NLEX assessment mainly used ex-post data. This is due to the publication time of the respective project reports. Note that the SuRe SmartScan outcome is classified into three categories ('leading', 'commended', 'drawbacks / room for improvement'). In section 3.2 it is explained that the SuRe SmartScan questions are answered by choosing out of three to four different levels (depending on the question) according to the project's engagement in the respective themes. Thus, the three categories in the below list of the SuRe SmartScan result summarize the achieved levels of the project in the corresponding issues. These categories are used in all of the subsequent case studies.

Figure 6 SuRe SmartScan assessments for SLEX and NLEX

South Luzon Expressway (SLEX)



North Luzon Expressway (NLEX)



Global Infrastructure Basel

Leading

South Luzon Expressway (SLEX)	North Luzon Expressway (NLEX)
• Existing social, economic and environmental liabilities included in planning • 60-100% of materials taken from recycled or reclaimed sources	• Execution of an Environmental and Social Impact Assessment (ESIA) and maintenance Environmental and Social Management System (ESMS) • Clear organizational setup with separation of roles • Transparent multi-disciplinary decision-making process • Sustainability manager and external monitoring in place • Completion of an environmental, social and economic risk assessment • Access to services from the infrastructure in poor areas has improved over the last few years and efforts will continue • 60-100% of materials sourced from within the specified distances • More safety against flooding and reduced greenfield consumption due to partial construction of the toll road on stilts

Commended

South Luzon Expressway (SLEX)	North Luzon Expressway (NLEX)
• Carrying out of an Environmental and Social Impact Assessment (ESIA) • Implementation of concrete resilience measures (natural disasters, conflicts, health epidemics and emergency migration) in collaboration with relevant actors • Assessment of the risks of flooding, erosion and landslides • Stakeholder engagement with reporting to the management • Clear operational setup • Compliance with all relevant laws • Compliance of employment policies with national and international law • Protection of minorities and indigenous people and minimization of impacts • Promotion of hiring and training local staff • Monitoring of socioeconomic indicators • Assessment and monitoring of impacts on biodiversity, natural habitats and the ecosystem • No deforestation or 100% compensation • Waste reuse strategies in place • No impact on water source volume or quality • Geotechnical assessment of the site's suitability for the project	• Implementation of concrete resilience measures (natural disasters, conflicts, health epidemics and emergency migration) including periodic drills • Assessment of the risks of water scarcity, sea-level rise, heat waves and increased population • Evaluation of potential suppliers' sustainability • Stakeholder engagement with reporting to the management • Compliance with all relevant laws • Compliance of contractors/subcontractors with the occupational health and safety policy • Protection of minorities and indigenous people and minimization of impacts • Promotion of hiring and training local staff • Monitoring of socioeconomic indicators • Assessment of impacts on biodiversity, natural habitats and the ecosystem with continuous improvement • No deforestation or 100% compensation • Waste reuse strategies in place • No impact on water source volume or quality • Geotechnical assessment of the site's suitability for the project

Drawbacks / Room for improvements

South Luzon Expressway (SLEX)	North Luzon Expressway (NLEX)
• No assessment with regard to water scarcity, sea-level rise, heat waves and increased population • No sustainability analysis of supply chains • Limited participation of affected communities • No specific sustainability/resilience manager • No signs of human rights abuses but no public disclosure either • No particular promotion of equal opportunities and non-discrimination • No compliance of subcontractors with occupational health and safety policies • Resettlement of people due to the project • No monitoring of GHG emissions • No use of renewable energy • Improvement of the emergency preparedness plan needed • No emphasis on storm waters	• Limited participation of affected communities • No inclusion of "system thinking" • Improvement in anti-corruption and transparency policies needed • No signs of human rights abuses but no public disclosure either • No particular promotion of equal opportunities and non-discrimination • No monitoring of GHG emissions • No use of renewable energy • Improvements in the emergency preparedness plan needed

4.1.3 Post-disaster assessment

To start this part of the measurement procedure, we give an overview of the natural disasters of the last ten years in the Philippines. It shows that their number is quite large. The most prominent ones are tropical cyclones, floods and earthquakes. In 2013, the above-mentioned cyclone Haiyan caused a high number of fatalities even though it did not pass through Manila.

Table 4 Summary of natural disasters in the Philippines 2006 – 2016

Disaster type	Disaster subtype	Occurrence	Total deaths	Total number of people affected	Total damage ('000 USD)
Drought	Drought	2	0	181,687	84,399
Earthquake	Ground movement	6	344	3,575,801	63,693
Epidemic	Bacterial disease	3	53	3,975	0
Epidemic	Viral disease	2	770	130,717	0
Flood	Coastal flood	2	11	50,034	2,520
Flood	Riverine flood	41	565	13,938,182	2,381,338
Flood	Flash flood	23	204	3,786,769	269,284
Flood	--	9	97	1,620,056	9,520
Landslide	Avalanche	1	6	1,200	0
Landslide	Landslide	9	1,277	20,334	2,281
Storm	Tropical cyclone	100	15,887	84,131,418	16,593,176
Storm	Convective storm	1	0	100	5
Volcanic activity	Ash fall	6	0	153,114	0

Source: CRED (2017)

For our investigation, we have to make a selection and choose the disasters that were related to Manila. Therefore, we focus on the two tropical storms Ondoy (Ketsana) and Pepeng (Parma), which occurred within two weeks in September and October 2009. It was estimated that damage and losses amounted to a total of USD 4.38 billion. The post-disaster needs assessment (World Bank, 2011), executed by representatives of the private sector and civil society organizations, multilateral development partners, bilateral development partners, and the governments of various countries, presents an outstandingly detailed explanation of the post-disaster effects within the following sectors:

Agriculture	480,000 affected farmers; main damage and losses in crop irrigation; approx. USD 274 million needed for recovery
Enterprise sector	USD 1.7 billion in forgone revenues in manufacturing, wholesale, retail, trade and tourism combined
Housing sector	220,000 homes completely or partially damaged by floodwaters; hundreds of thousands homeless
Education sector	3,417 schools, 36 colleges and about 2,800 day care centers affected or damaged; damages and losses of USD 54 million in total
Cultural heritage	Over 45 cultural heritage sights were damaged
Health	Recovery and reconstruction of public sector facilities - around USD 40 million
Electricity sector	Damages of USD 32 million
Water supply	More than 50 water supply systems damaged mainly in Metro Manila
Transport sector	Total damage and losses of USD 150 million; types of damage included landslides, eroded/washed out shoulder materials, embankments, and bridges; Road infrastructure was the most affected; recovery and reconstruction needs amounting to USD 233 million
Telecommunications	Extensive damage to telecommunications infrastructure; cost of repairs USD 4 million
Impact on employment and livelihoods	A total of 172 million workdays were lost (= 664,000 one-year jobs), which resulted in losses amounting to USD 1 billion of income in 2009
Financial sector	Trade volume first fell by 50%, and then by 25% during the two days before Ondoy struck

Source: World Bank (2011)

The following table contains a list of all post-disaster indicators for these two tropical storms, and also with regards to SLEX and NLEX. Since they occurred shortly one after the other, many indicators are presented in a summarized way.

Table 5 Indicators of disasters in Manila

	Tropical storm Ondoy – September 2009	Tropical storm Pepeng – October 2009
Macro and Meso Level	• Total deaths: 464 • Total injured: 529 • Missing: 37 • Total affected: 4,901,234 • Immediate search and rescue operations in the flooded areas • Request for international assistance right after the storm	• Total deaths: 492 • Total injured: 207 • Missing: 47 • Total affected: 4,478,284 • Early warning and evacuation of around 45,500 people
	Indicators describing both storms jointly: • Ambiguous impact on economic growth • Poverty incidence increased by 3 percentage points in most affected areas of Luzon • Majority of population affected, homes flooded • Reconstruction cost per residence between 12,000 and 141,000 Pesos depending on income class of households • Severe losses of household assets for 45 percent of the households • Interruption of water supply for 22 days • Income loss of 21,000 Pesos per household • Medical expenses of 6,517 Pesos per household	
SLEX / NLEX	• NLEX: USD 1.6 million in damages and losses (total transport damages and losses USD 150 million) • Part of the SLEX and NLEX was flooded	

Sources: World Bank (2011); Porio (2012)

4.1.4 Resilience Dividend

The Resilience Dividend of the two Manila projects is portrayed in two components: first, the avoided losses after the two tropical cyclones of 2009 are analyzed according to the above shown indicators. Second, the SRBA assesses the additional benefits of the two analyzed toll ways in absence of disasters. The comparison of these two expressways will show whether the Resilience Dividend can be confirmed. If there are more benefits for the project, which exhibits a better SuRe SmartScan result, we get the confirmation that resilience efforts pay off.

Avoided losses due to disruption preparedness

Table 6 Resilience Dividend in a disaster case

Dividend	Description	
	South Luzon Expressway (SLEX)	**North Luzon Expressway (NLEX)**
Financial Dividend	• Avoided losses from daily operation	• Avoided losses from daily operation
Human Dividend	• Secured access to basic needs	• Secured access to basic needs
Natural Dividend		• Better drain off of water submerged areas due to improved drainage system
Physical Dividend	• Better and more reliable access to provide basic needs (health and sanitation, food, water, shelter etc.) in a state of emergency	• Better and more reliable access to provide basic needs (health and sanitation, food, water, shelter etc.) in a state of emergency • Early warning system in place, which produces alerts before, during and after an event • Construction of viaducts in the wetlands on stilts: less flooded roads
Political Dividend	• Addressing citizens' requests for public discussions on road infrastructure	• Addressing citizens' requests for public discussions on road infrastructure
Social Dividend	• Faster recovery to a normal work-day	• Faster recovery to a normal work-day

Additional benefits in absence of a disaster (SRBA)

Environmental

- Absorption of GHG emissions due to new trees along the expressways (SLEX and NLEX) (Santos et al., 2009; DENR, 2011)

Social

- SLEX: time saving of almost 50%, vehicle operating cost savings of 1.38 Pesos per km, NLEX: Improved safety, lighting, signage and enforcement of traffic laws (ADB, 2010)
- NLEX: alerts on congestion weather, traffic etc. for the whole population due to traffic management system
- SLEX and NLEX: reduced travel times
- SLEX and NLEX: increased safety through speed limits and wider lanes
- SLEX and NLEX: improvement in gender equality with training, public information and provision of sanitation facilities

Governance

- NLEX: benchmark for other toll road projects in the Philippines (ADB, 2011)
- NLEX: Role model for future PPP in infrastructure

Economic

- NLEX: strong increase in the number of billboards along the road as an indicator of an economic upswing (ADB, 2010)

- NLEX: rise in tourism (number of visitors increasing by 24% from 2007 to 2008) (ibid., 2010)
- NLEX: creation of 5,000 new jobs (ibid., 2010)
- NLEX: increase in operating revenues
- NLEX: Increase in tax income from expressway operation
- SLEX: increase in operating revenues

4.1.5 Interpretation of the Resilience Dividend

The SuRe SmartScan yields a good result for the SLEX and a very good result for the NLEX. Indeed, there is a positive Resilience Dividend for both projects. After a disaster, both are able to keep up operations or to re-establish them soon if they have been interrupted. Thanks to early warning systems, the NLEX is a little better prepared for emergencies. Both highways are especially important to enable people's mobility and the delivery of emergency services in the disaster case. What is missing for the SLEX, however, is a clearly defined natural dividend after a disaster.

The co-benefits in the absence of a disruption are also visible while more indicators are measured for the NLEX. Most of them are of a social or economic nature and concern smooth operations and usage of the expressways as well as business dynamics that have been sparked. It has to be noted that, in a metropolis as densely populated as Manila, the capacity of the previously existing road network were often exceeded, resulting in regular traffic congestion. Hence, the case to build new toll roads was present (Boquet, 2015, p. 460). On the other hand, additional traffic capacities mean additional environmental pollution. This problem is clearly revealed in the SuRe SmartScan results for both SLEX and NLEX as they both feature quite low values in relation to climate issues.

4.2 Mathbaria

4.2.1 Background

Macro and Meso Level

According to the INFORM index, Bangladesh has a quite high hazard and risk exposure (rank 15 out of all countries) (2017). This is closely connected to the findings of National Geographic, which state that Bangladesh and India are the two countries most vulnerable to the impacts of climate change (2010). On the city level, the Lloyd's City Risk Index shows that, despite good economic growth prospects, a large share of GDP in Bangladesh's Capital Dhaka is threatened by potential disasters (Lloyd's, 2015). Among the ten riskiest disasters in Bangladesh, natural disasters account for about half of GDP@Risk.

- Average GDP growth rate: 6.19%
- Average annual GDP: USD 36.76bn
- Total GDP@Risk: USD 6.57bn
- Share of average annual GDP: 17.86%

Source: Lloyd's (2015)

Table 7 GDP@Risk in Dhaka

Threat	GDP@Risk	Share of total GDP@Risk
Market crash	USD 1.57bn	23.95%
Flood	USD 1.07bn	16.29%
Human pandemic	USD 1.05bn	15.96%
Earthquake	USD 0.94bn	14.26%
Sovereign default	USD 0.92bn	14.05%
Oil price shock	USD 0.44bn	6.65%
Power outage	USD 0.17bn	2.59%
Drought	USD 0.14bn	2.19%
Wind storm	USD 0.10bn	1.54%
Solar storm	USD 0.06bn	0.86%
Cyber attack	USD 0.05bn	0.79%

Source: Lloyd's (2015)

Micro Level: the Mathbaria Project

The Mathbaria project is part of a large project of the Asian Development Bank (ADB) and the Rockefeller Foundation led Asian Cities Climate Change Resilience Network (ACCCRN) comprising resilience improvements in eight coastal towns in Bangladesh. In particular, the project provides climate-resilient infrastructure and aims at strengthening institutional and governance capacities, for instance by fostering transparency and anti-corruption measures, as well as disaster preparedness. Overall project costs are budgeted at USD 117.1 million. GIB chose Mathbaria out of these eight cities because it is the project, which takes the most comprehensive account of resilience aspects, i.e. it comprises all envisioned infrastructure measures in one single town: it consists of several subprojects. First, there is a water supply subproject because there is currently no piped water in Mathbaria. Moreover, an additional cyclone shelter is being constructed because the current shelter capacity is insufficient. Furthermore, river embankments are being strengthened and the city's drainage system is being improved. And finally, some roads and a bridge have been restored.

Mathbaria is the joint case to be investigated by both the RAND Corporation and GIB. This section presents GIB's contribution. It is an exceptional case because it analyzes resilience on the city level rather than on the level of an individual project. However, the tools can be applied in an analogous way. Due to the city-level analysis, the number of potential stakeholders is large. Basically, the whole city population and particularly the most vulnerable and poor people are affected by the project. Regional and city authorities naturally have a great interest in this project as well, as they get funding support and receive governance support. Furthermore, the civil society has particular interests in the project aspects that concern environmental or social issues. Other stakeholders include locals living in the villages around Mathbaria, since they may for instance find shelter when disasters occur in their region.

As stated repeatedly, data availability is the main bottleneck in this study's approach to real infrastructure projects. Since the project has not yet been fully realized, the concept has to be adapted. In particular, the situation prior to project realization is taken as the initial situation. The damages and losses incurred during the disasters, as well as many additional problems and challenges, indicate the need for improvements to Mathbaria's resilience. GIB investigated how far the project at hand responds to these needs in order to get an idea of whether Mathbaria will be prepared for future catastrophes. In this way, the Resilience Dividend can be approximated.

Data for the SuRe SmartScan assessment and the SRBA are contained in the ADB project reports. On the one hand, there is the main report for the overall project for all eight towns (GHK Consulting Limited, 2013). On the other hand, the Mathbaria project is documented in three different reports concerning the water supply sub-project, a resettlement plan and the cyclone shelter subproject respectively (Government of Bangladesh, 2013a, 2013b, 2013c). Additional sources used in specific places are indicated accordingly.

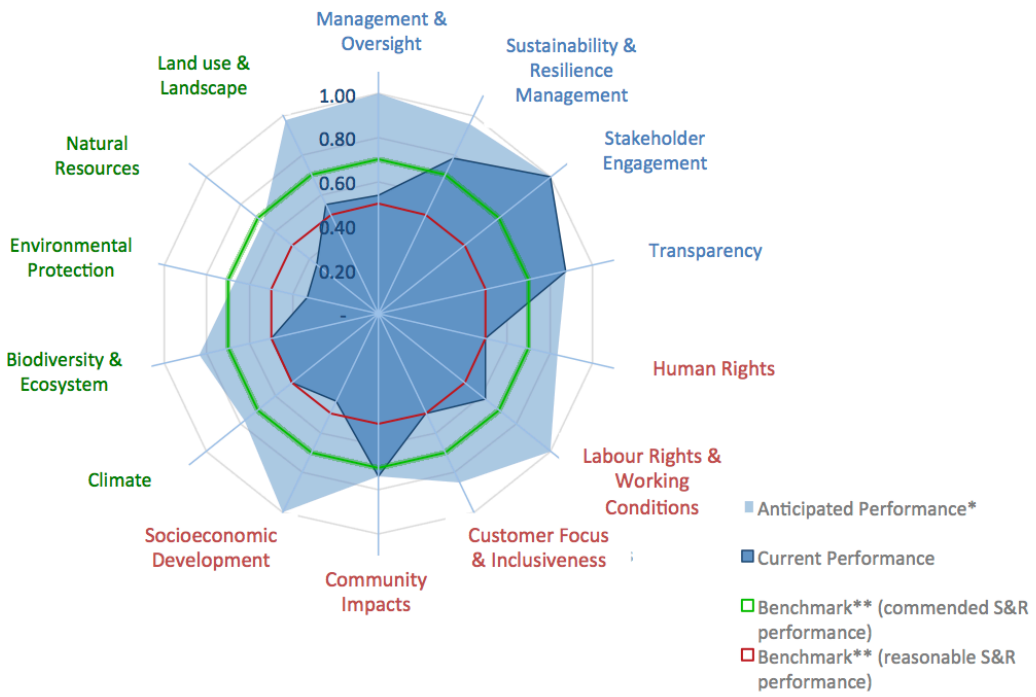
Data used (see references for full citation)

- Project reports (retrieved from ADB)
- Various academic articles
- Online news articles
- Various stakeholder websites

4.2.2 Resilience level assessment

The SuRe SmartScan reveals the following project characteristics: overall, the rating is quite high as the commended benchmark is reached for almost all themes with either current or future measures. Specifically, there is a strong emphasis on institutional and governance issues as for example sophisticated stakeholder inclusion and sustainability training for employees. As described above, the project does not only take resilience into account but is rather directly dedicated to build resilience. The list below provides a short summary of the projects resilience and sustainability level according to the SuRe SmartScan. The interpretation of these findings is presented at the end of this case study analysis.

Figure 7 SuRe SmartScan assessment for the Mathbaria resilience improvement infrastructure project



Leading

- Clear organizational setup of the project
- Employees provided with training for sustainability skills

- Established anti-corruption policy
- Employment of local staff has first priority
- Project-specific gender action plan with targets and measures
- Complaint and grievance mechanism to eliminate discrimination
- Stakeholder engagement is an on-going process throughout the implementation phase
- Accounting for a broad range of risks and emergencies:
    - Environmental: sea-level rise, intensifying cyclones and floods
    - Social: health epidemics (fresh water supply and sanitation)
    - Governmental: technical/operational risks, urban planning risks, governance risks
- Concrete emergency preparedness measures:
    - Cyclone shelter
    - Drainage and flood controls (construction of earthen channels and drains)
    - Water supply (construction of pipelines, well drilling etc., back-up generators)
    - Sanitation (public toilets, school latrines etc.)
    - Improvement of river embankments
- Improved sanitation conditions for city population
- Intergovernmental Panel on Climate Change (IPCC) scenarios are taken into account
- Use of hazardous materials minimized
- No threat to forests, wetlands or mangroves
- Flooding caused by storm water flows prevented
- Waste recycling

Commended

- Separation of roles in the construction and operation phases
- Sustainability manager
- Employment conditions according to ILO conventions
- Public meetings for information disclosure
- Positive spillover effects on the areas around Mathbaria through increased income as well as improved resilience
- Better flood and cyclone protection raises investment security
- All revenue-generating subprojects are judged as financially viable
- Impacts on biodiversity and ecosystems are monitored
- Standards set for water quality, air pollution and noise

Drawbacks / Room for improvement

- No specific emphasis on health and safety conditions during project implementation
- Renewable energies and energy efficiency not emphasized
- Resource efficiency not emphasized

4.2.3 Post-disaster stress assessment

Disasters

Floods and storms (often in the form of cyclones) are the natural disasters that hit Bangladesh most often. As Table 8 shows, they have also have caused the most fatalities and damage during the past ten years.

Table 8 Summary of natural disasters in Bangladesh 2006 – 2016

Disaster type	Occurrence	Total deaths	Number of injured people	Total number of people affected	Total damage in USD ('000)
Drought	1				
Earthquake	2	9	270	270	
Epidemic	2	86		284,910	
Extreme temperature	5	399		327,000	
Flood	18	1,634	21,160	29,255,237	314,000
Landslide	4	103	153	56,283	
Storm	28	5,098	65,523	18,891,544	2,634,000

Source: CRED (2017)

There were many different disasters during the past ten years. This study focuses on those with a direct impact on Mathbaria. Table 9 gives an overview using a considerable number of indicators. In some cases, effects can be directly attributed to Mathbaria, while others have to rely on higher-level data. Nevertheless, the latter can still yield conclusions that are relevant for Mathbaria.

Table 9 Indicators of disasters in Mathbaria

Disaster	Indicators	Mathbaria related
Super Cyclone Sidr 2007[1]	• Number of killed people: 3347 and 871 missing • Number of affected people: 8,923,259 • USD 26.309 million of damage to water infrastructure • Long-term reconstruction cost USD 294 million • 12,984 water sources damaged (10,412 restored by end of 2007) • 5982 ponds damaged • Totally ruined cropland in four worst affected districts: 55,950 ha, partially damaged: 472,505 ha • Loss of production in four worst affected districts: 535707 MT • Damaged houses: 563,877 fully, 955,065 partially • 4 million trees destroyed • Among 475 jetties, 103 damaged • 125.40 km of embankment fully washed out • 9 km of riverbank heavily damaged • 8075 km roads affected • 3705 school buildings totally or partially damaged	Mathbaria was among the worst hit Upazilas (administration unit) in Pirojpur (province), which is itself one of the worst affected districts
Cyclone Aila 2009[2]	• Number of people killed: 190 • Number of people affected: 3,037,529 • Affected people in Pirojpur: 300,000 • Monetary losses: USD 269.28 million	Mathbaria experienced 6-7 feet of water
Cyclone Mahasen May 2013[3]	• Number of people killed: 17 • Number of people affected: 1,258,508 • Crop losses: USD 5.14 million	• 1 dead in Mathbaria • 13'960 affected people

Table 9 *continued*

Flood and cyclone Komen June/July 2015[4,5]	• Number of people killed: 56 • Number of people affected: 2,610,000 • Monetary losses: USD 40 million • Pirojpur: 60'690 people affected, 1 death • Around 6000 houses completely or partially damaged	• Collapse of embankment due to river bank erosion • Only 50 shelters were available in Mathbaria; a shelter could accommodate around 200-400 persons

Sources: [1] Ministry of Food and Disaster Management, 2007; [2] Ministry of Food and Disaster Management, 2013; [3] Ministry of Disaster Management and Relief, 2013; [4] Nirapad, 2015, p. 4; [5] Dhaka Tribune 2015

Stresses

Besides the disasters, there are numerous problems and challenges as part of a wider trend in southern Bangladesh including widespread poverty that specifically concern the Mathbaria region. Many exist irrespective of disasters, but often have mutual interrelations with such disasters and may enhance their impacts. The following issues should be taken into account when trying to build resilience in Mathbaria and the ADB project:

- Highly seasonal hydrology: there are droughts in spring and heavy monsoon rains thereafter. Each state has different issues.
- Cholera: both drought and rainy seasons often give rise to cholera epidemics. Shafqat Akanda et al. (2012, p. 11), describe Mathbaria as a 'large scale driver' of cholera outbreaks. There were cholera outbreaks in Mathbaria in 2004 and 2005 (Mahapatra et al., 2014, pp. 148–150).
- Salinity: Rising salinity of soils threatens the availability of drinking water and freshwater for agricultural production In Mathbaria city. 65 percent of the area is affected by salinity (Rahman & Rahman, 2015, pp. 99–100).
- Arsenic: groundwater of a large part of the coastal zone is contaminated by arsenic. Mathbaria is right in the center of this area (ibid., 2015, p. 102).
- Spatial expansion: unplanned urban development makes it more difficult to provide sanitation, drinking water and effective flood protection.
- Migration: due to increasing difficulties in agricultural production and the threat of cyclones, floods, droughts and erosion, there is a strong migration movement from the coastal areas to the Capital Dhaka (ibid., 2015, p. 104–105).

In relation to these facts, there are additional problems in times of natural disasters:

- Waterlogging: relatively little rainfall can flood large areas in coastal cities due to insufficient and ineffective drainage infrastructure. Water cannot recede and therefore damages agricultural land. Flood impacts are worsened by the construction of artificial canals used for shrimp production and polders (Rahman & Rahman, 2015, p. 100–101).
- Mangroves: there is insufficient coastal vegetation near Mathbaria. A study shows that a 150m belt of mangroves would lower a storm water surge by 0.5-1m (Investigation Team of Japan Society of Civil Engineering, 2008, p. 62). Accordingly, the ADB initiated measures for the coastal town of Mathbaria are of utmost importance to counterbalance these challenges.

Finally, climate change amplifies many of the existing challenges and adds new ones. Cyclones and floods tend to become stronger. The expected rise in sea level will lead to salt water ingression into rivers. The availability

of fresh water will reduce, and seepage of seawater into the ground water will increase the salinity of soils (Rahman & Rahman, 2015, p. 100).

4.2.4 Resilience Dividend

Given that the project has not yet been fully implemented, the Resilience Dividend is estimated in the following way: the indicators of the losses incurred in the above disasters are first considered (refer to Table 9) and then compared with a SuRe SmartScan assessment. This allows an estimate to be carried out demonstrating how far the project gives convincing responses to existing risks and problems. For a Resilience Dividend to exist, the project should contain measures that correspond to issues that faced bad indicator values in the preceding disasters. The procedure for long-run stresses is analogous. Since there is no reference data due to the project's ongoing realization, it is not possible to provide definitive numbers. Nevertheless, there is a clear indication of the benefits. Final quantification may once be completed with more data. The same is valid for the various benefits in non-disaster situations, which are exhibited by the SRBA methodology.

Estimated avoided losses because of disruption and stress preparedness

Table 10 Expected Resilience Dividend in disaster cases

Dividends	Description
Financial Dividend	• Reduced material damages, reduced monetary losses • Less financial losses due to shorter recovery times as less reconstruction is required and can take place immediately • Limited loss of local work force due to saved lives
Human Dividend	• Greatly reduced number of fatalities due to shelter construction • Less cholera outbreaks thanks to improved sanitation and water supply • Increased awareness regarding personal emergency preparedness • Water supply not interrupted due to back-up generators • Faster emergency deliveries as new roads can better withstand disasters
Natural Dividend	• Less erosion along river embankments
Physical Dividend	• Less damage to roads, water supply and sanitation infrastructure • No destruction of water sources due to safe water supply • No waterlogging due to improved drainage system
Political Dividend	• Political acceptance due to thorough stakeholder inclusion
Social Dividend	• Better and arsenic-free water supply for the city population in the long run • More safety and risk reduction for the greater Mathbaria area including the agricultural sector • Reduction in migration due to better disaster resilience

Expected additional benefits in absence of a disaster (SRBA)

<u>Environmental</u>

- Cleaner environment due to minimized use of hazardous material
- Reduced agricultural crop loss due to flooding

<u>Social</u>

- Improved living conditions thanks to employment of local staff

- Improved access to hospitals, markets, schools, places of work etc., enabled by better roads
- Solid waste management: improved quality of life due to cleaner surroundings
- Access to reliable water supply system in the town by all residents
- Positive health impacts of water testing/quality supply
- Increased access to safe sanitation by all people, and specifically poor households, women and children
- Increased safety, security and dignity for women and female children (who will not have to practice open defecation)
- Potential raising of health and social status of manual workers engaged in desludging

Governance

- Institutional strengthening
- Reduced corruption due to corresponding measures
- Increased transparency

Economic

- Increased income due to reduced time spent on commuting
- Savings in road infrastructure operating costs
- Increased income due to employment of local staff
- Reduced medical costs due to decreased number of sick days thanks to improved sanitation and drainage system
- Increase in savings per household (as water charge per month envisaged will be lower than present direct opportunity cost for purchase of water)
- More investment security due to risk reduction
- Reduced storage tank cost thanks to better water supply system

4.2.5 Interpretation of the Resilience Dividend

The above analysis shows that the Mathbaria project can be expected to yield a clearly positive Resilience Dividend. Quantification is more difficult because the project has not yet been completed. However, it can be shown that the project responds to many problems, which are revealed by bad indicator values such as high numbers of fatalities following the above-mentioned disasters. In particular, we have good reasons to argue that human lives will be saved and material damages can be reduced. This project contains many elements that are recommended to develop a long-term adaptation strategy in coastal areas (see Barbier, 2014p. 1251). Moreover, several main disaster-independent and long-term stresses are addressed. For example, better water supply allows people to avoid drinking water that is contaminated by arsenic and salinity. Beside the Resilience Dividend in the form of a disruption response, there are also many benefits independent of a disaster such as employment creation, positive long-term health impacts and institutional improvements. Due to the projects ongoing implementation, we can only make an estimate of what the resilience dividend will be in the first disaster after project completion. Nevertheless, there are strong arguments that support the existence of the resilience dividend.

However, there are still some important issues that are not taken into account by the Mathbaria project. For instance, there are no measures to prevent the destruction of trees, which happened a great deal during super cyclone Sidr in 2007. Hence, there seems to be no natural Resilience Dividend in this respect. Similarly for the long-term stress of salinity, there is no strategy to cope with it systematically. All in all, however, it can be said that this bundle of infrastructure projects is quite effective in addressing most of the identified problems and challenges either in a disaster situation or in the longer term.

4.3 Quito

4.3.1 Background

Macro/Meso Level

Ecuador is exposed to natural hazards such as frequent earthquakes, landslides, volcanic activity, floods, and periodic droughts (CIA, 2017). According to the OECD (2017), Ecuador was the 69th largest exporter in the world in 2014. The main exports are crude petroleum (50%), bananas (12%), crustaceans (9.3%), processed fish (4.7%), gold (3.5%) and cut flowers (2.8%). This is an important issue in this context, since the chosen project of interest is an international airport – a hub for exports.

According to the INFORM country risk profile for Ecuador (2017), earthquakes, tsunamis and floods are the most prominent hazards for the country. Concerning overall risks, Ecuador is ranked 69th out of 191 in the world, and the trend for the next three years is stable. According to Lloyd's City Risk Index, Quito's fast-growing economy is exposed to a high level of risk (Lloyd's, 2015). In particular, about one third of the capital's economic output is at risk due to disruptions of various kinds. As Table 11 shows, natural disasters make up almost 75 percent of the GDP@Risk.

- Average GDP growth rate: 5.76%
- Average annual GDP: USD 35.32bn
- Total GDP@Risk: USD 11.70bn
- Share of average annual GDP: 33.13%

Source: Lloyd's (2015)

Table 11 GDP@Risk in Quito

Threat	GDP@Risk	Share or Total GDP@Risk
Earthquake	USD 6.00bn	51.25%
Volcano	USD 2.22bn	18.98%
Market crash	USD 1.52bn	13.00%
Sovereign default	USD 0.83bn	7.06%
Human pandemic	USD 0.82bn	6.97%
Power outage	USD 0.08bn	0.70%
Solar storm	USD 0.05bn	0.46%
Flood	USD 0.05bn	0.45%
Cyber attack	USD 0.05bn	0.43%
Terrorism	USD 0.05bn	0.41%
Plant epidemic	USD 0.04bn	0.30%

Source: Lloyd's (2015)

Micro Level: New Quito International Airport Project

The New Quito International Airport projected is located close to the capital city and was developed to replace Mariscal Sucre Airport. It handles more than 5 million passengers every year and serves as an export hub for up to 20 million roses per day (Chalk & Beane, 2014). The project cost for building this new airport was USD 700 million. Most important stakeholders belong to the exporting sectors of the Ecuadorian economy, the tourism branch, as well as the national and city governments. Moreover, the population within the project zone, airport staff and NGOs – specifically those with an interest in the high biodiversity of the previous greenfield site –

each have their own particular interests. Further stakeholders include the city population and international financial institutions investing in the airport project.

In 2016, there was a strong earthquake with a magnitude of 7.8 in the area surrounding Quito. At about the same time, volcanic activity threatened economic life in the capital. In this particular case study, GIB investigated how the new airport responded to these disruptions and evaluated whether the specific resilience measures observed in the SuRe SmartScan assessment were effective.

The project was partially funded by the Inter-American Development Bank (IDB) and partially by other companies from various American countries. The data used are mainly those provided by the IDB's Final Environmental Impact Assessment (Komex, 2003). Other sources are indicated.

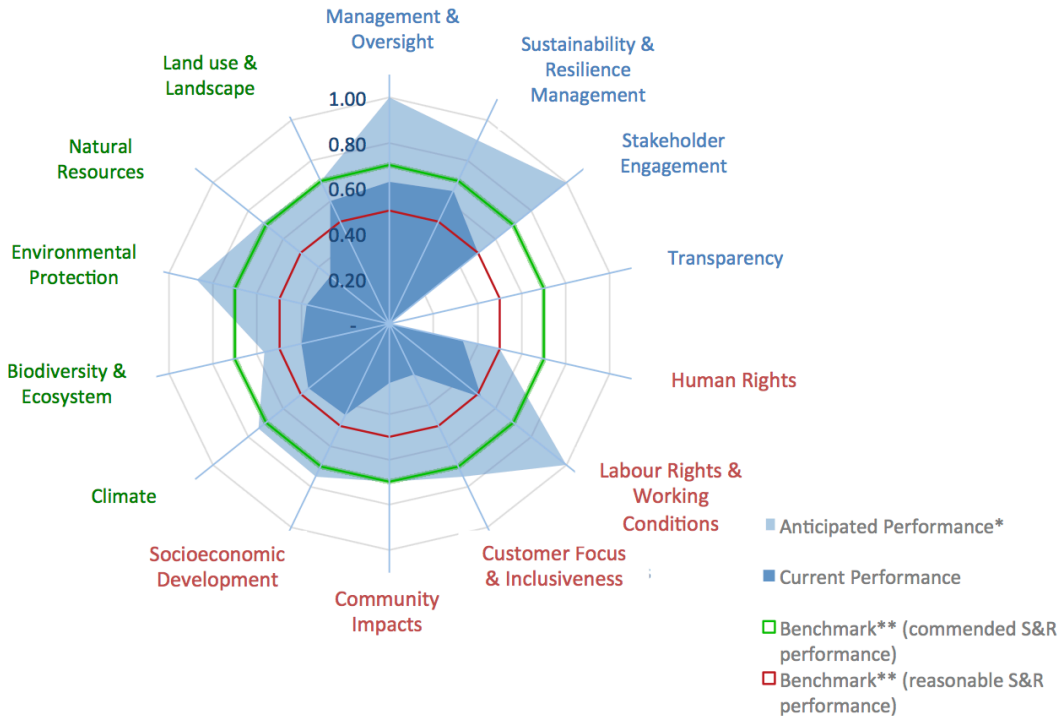
Used data (see references for full citation)

- Environmental Impact Assessment (retrieved from IDB)
- Various academic articles
- Online news articles
- Various stakeholder websites

4.3.2 Resilience level assessment

The SuRe SmartScan reveals the following project characteristics: overall, the rating for Quito airport is good, with the governance part being rated very good. Unfortunately, data on transparency and anti-corruption policies are completely missing, which prevents any definitive conclusions being made in this regard. However, it can be seen that resilience aspects are emphasized in detail. On the other hand, there is still potential in social and environmental themes. Therefore, the airport seems to be well prepared for disasters but may still improve its performance in times of non-disruption.

Figure 8 SuRe SmartScan assessment for the Quito airport project



Leading

- Environmental and Social Impact Assessment (ESIA) and Environmental and Social Management System (ESMS)
- Life cycle thinking when planning and operating (including impacts for future users)
- Accounting for highly relevant risks and emergencies:
    - Environmental: seismic activity, landslides, volcanic hazards
    - Social: risks to public health and safety
- Concrete emergency preparedness measures:
    - Regional monitoring and early warning system
    - Training drills carried out jointly with other stakeholders
    - ESG risk training and education
    - Structure designed to resist seismic activity
    - Emphasis of evacuation routes and emergency protocols (Georgoulias et al., 2014, p. 143)
- Accounting for pre-existing liabilities and grievances
- Exceptional stakeholder engagement during all phases of the project
- Clear organizational setup and transparent decision-making process
- Employment of a sustainability manager; external monitoring
- Fair and non-discriminatory employment terms and conditions compliant with international best practice
- Occupational Health and Safety (OH&S) management system
- 10% more trees than before project realization

Commended

- Systems thinking in relation to the overall master plan (national, regional)
- Minimization of the number of displaced people
- Study on cultural heritage and minimization of potential impacts on cultural heritage
- Employment of local staff and further training for local skills
- Local procurement of material
- Assessment of potential contribution to wider socioeconomic development, for example: changes, stresses placed on local and regional infrastructure and community services etc.
- Consideration of project-related impacts on biodiversity, natural habitats and the intactness of ecosystems with contiguous improvement (adaptive management)
- No introduction of species with a high risk of invasive behavior
- Waste re-use strategy
- Air, water and soil based pollution targets
- Noise, vibration and light levels compliant with national and/or international standards
- No significant impact on storm water flow patterns

Drawbacks / Room for improvement

- No data regarding transparency
- No reporting on human rights of contractors and subcontractors.
- No clear consideration of long-term impacts such as those caused by decommissioning / climate change
- No focus on poor customers
- Further efforts to minimize GHG emissions needed
- No emphasis on energy efficiency, renewable energy and embodied energy
- Negative impacts on water source volume and quality
- Loss of greenfield

4.3.3 Post-disaster assessment

The overview of disasters in Ecuador in the past ten years shows that earthquakes, floods and volcanic activities are the most prominent. Natural disasters caused the most fatalities and damage.

Table 12 Summary of natural disasters in Ecuador 2006 – 2016

Disaster type	Disaster subtype	Occurrence	Total deaths	Total number of people affected	Total damage ('000 USD)
Drought	Drought	2	0	110,665	1,700
Earthquake	Ground movement	3	680	1,230,165	3,300,000
Epidemic	Viral disease	2	15	10,967	0
Flood	Riverine flood	10	115	491,706	1,002,800
Landslide	Landslide	3	31	150	0
Volcanic activity	--	2	9	140,042	10,000
Volcanic activity	Lava flow	1	0	800,000	0
Volcanic activity	Ash fall	3	5	302,763	150,000
Wildfire	Forest fire	1	5	1,945	0

Source: CRED (2017)

The Quito case study focuses on the 7.8 magnitude earthquake in 2016 and various volcanic activities within the last two years. Table 13 shows how these disasters have affected the region, and in particular the airport of Quito. The indicators inform in how far the project was able to withstand the disasters and to keep up its operations.

Table 13 Indicators of disasters in Quito

	Macro and meso level indicators	Micro level indicators
2016 Earthquake (including aftershocks)[1,2,3]	• Total deaths: 676 • Total people affected: 1,230,000 • Total damage: USD 3,300,000,000 • Magnitude: 7.8 • Parts of the capital left without power or telephone service	• Total deaths: 0 • 4.6 magnitude aftershock in Quito: temporary interruption of operations at the airport • Three days after the earthquake: airport back to normal operation • Assessment of the airport infrastructure by crisis coordination committee confirms good state • Suspensions and delays at other airports
Volcanic Activities 2015 and 2016[4,5]	• Total people affected: 930,042 • Spread of fine grey powder in area with radius of 30 km • Loss of flower exports due to ash • Decrease in milk production due to ashes destroying acres of pasture	• Approaches in place for flights to avoid volcano instead of cancelling them • Airport operations remain open • Airport crisis coordination committee active to anticipate changes in situation

Sources: [1] Elgot et al. (2016); [2] teleSUR (2016); [3] Breaking Travel News (2016); [4] Gupta (2016); [5] Jean (2015)

4.3.4 Resilience Dividend

Since there is no reference project, we compare the new airport's performance with the suggested performance in the case the resilience measures would not have been taken. This does not allow for an observable direct comparison but is nevertheless based on arguments that rely on data: the Resilience Dividend component in the form of avoided losses after the earthquake is justified by the observed indicator values in Table 13. Likewise, the SRBA approach detects the benefits arising from the airport in times of no disaster.

Avoided losses because of disruption preparedness

Table 14 Resilience Dividend in a disaster case

Dividend	Description
Financial Dividend	• Increase in national income as flow of tourists can be maintained (2015: 706,000 tourists in Quito) • Security of operations provides daily cash flow. Operation data: 167 daily flights, 14,730 passengers per day and 516 tons of cargo per day[1]. Any interruption of operations yields a corresponding loss. • Financial savings due to reduced reconstruction needs (reconstruction costs would be quite expensive as 95% of the country's infrastructure is not insured)[2]
Human Dividend	• Security of 14,730 passengers per day
Natural Dividend	• Integration of water bodies in the surrounding area to prevent water contamination and flooding (Georgoulias et al., 2014, p. 132)
Physical Dividend	• Essential contribution to emergency support and recovery in areas affected by the earthquake as material deliveries and donations can be imported thanks to safe operations[1]
Political Dividend	• Improved coordination and collaboration with political authorities
Social Dividend	• Accessibility to and from Quito

Sources: [1] Quiport (2016a); [2] SMIC (2006, p. 7)

Additional benefits in absence of a disaster (SRBA)

<u>Environmental</u>

- Less congestion in Quito city, where the old airport was located
- Provision of public transport service between Quito and airport

<u>Social</u>

- Improvement of air quality in dense urban area
- Reduced health and safety risks for population
- Potential for archeological findings as some traces were found during excavation at the new airport site
- Integration of water bodies in the surrounding area to prevent water contamination and flooding (Georgoulias et al., 2014, p. 132)
- Inclusion of the community needs of the six neighboring parishes in terms of training, employment, new businesses and industries (ibid., p. 126)
- Investments in sporting facilities and equipment, and education programs in the surrounding communities (ibid., p. 129).

- Protection and preservation of cultural and historical resources that are important to local communities (ibid., p. 129).
- Reintegration of the old airport in the city; creation of a park for leisure activities etc.

Economic

- Update of existing road from Tumbaco to Yaruqui, two municipalities in the vicinity of Quito
- Socioeconomic development in terms of growth in tourism, agriculture, and product exports (Georgoulias et al., 2014, p. 126)
- Establishment of a communal enterprise for solid waste management
- More people spend time in Quito: opening of hotels and restaurants (Panamerican World, 2016)

Governance

- Wildlife control program: trained birds of prey are held in the airport area to prevent other animals from entering the airport zone in order to ensure the safety of airport operations (Quiport, 2016b)

4.3.5 Interpretation of the Resilience Dividend

It goes without saying that a positive Resilience Dividend can exist when there is a disaster as well as during normal times. Even though the disruptions described above took place partially in the wider Quito area rather than directly in the center of the city, it is clear that the airport administration is well prepared for disasters. Hardly any of the airport operations were interrupted. These strong institutional skills correspond quite well with the high resilience level achieved in governance themes in the SuRe SmartScan. Moreover, the strong emphasis of natural disasters in the project planning phase seems to be reflected in the good performance during the disasters. Even though an individual infrastructure project is considered, there is a clear connection to the city-level and even national resilience needs: as we are dealing with an airport which is the country's most important bottleneck for imports and exports, the resilience level of this project is important for the resilience of the whole country. A part of the Resilience Dividend thus consists of the airport's ability to deliver emergency material and aid to the areas that are most affected by disruptions. Against the background of the country risks indicated by the Lloyd's index, and the happenings during the strong earthquake, we see that resilience efforts eventually pay off.

The non-disaster related benefits are clearly visible. There are benefits in all areas, but they mainly concern social issues. However, there are also some losses, which include the reduced biodiversity at the airport site, which was previously greenfield. Moreover, there are no specific measures to account for increasing noise pollution in the parts of the city surrounding the airport.

4.4 Port-au-Prince

4.4.1 Background

Macro/Meso Level

Haiti is exposed to various kinds of disruptions. In the INFORM overall risk index, it is ranked 14th of all countries (2017). As a consequence, economic production and national wealth are jeopardized. The following numbers relating to the economy in Haiti's capital Port-au-Prince show that, despite high growth rates, it is still very poor. Additionally, more than a third of GDP is threatened with being lost due to disasters. This is a quite high value and indicates that resilience is not very well developed in Haiti, and particularly in Port-au-Prince. Table

15 shows that this third of the so-called GDP@Risk is caused mainly by the following natural catastrophes: wind storms, earthquakes, human pandemics, floods, droughts and plant epidemics. In particular, 72.13% of the GDP@Risk is endangered by natural disasters.

- Average GDP growth rate: 5.11%
- Average annual GDP: USD 1.43bn
- Total GDP@Risk: USD 0.52bn
- Share of average annual GDP: 36.06%

Source: Lloyd's (2015)

Table 15 GDP@Risk in Port-au-Prince

Threat	GDP@Risk	Share or Total GDP@Risk
Wind storm	USD 0.24bn	45.89%
Sovereign default	USD 0.07bn	14.11%
Earthquake	USD 0.05bn	9.16%
Market crash	USD 0.04bn	8.26%
Human pandemic	USD 0.04bn	7.17%
Flood	USD 0.03bn	5.65%
Oil price shock	USD 0.02bn	3.29%
Drought	USD 0.01bn	2.57%
Plant epidemic	USD 0.01bn	1.69%
Power outage	USD 0.01bn	1.28%
Cyber attack	USD 0.00bn	0.00%

Source: Lloyd's (2015)

Micro Level: the Port Project

Port Lafito is the new port of Port-au-Prince. It is located in Lafiteau, which is a village quite close to the capital. The total project cost was USD 65 million (Haiti libre, 2015) and the port opened in June 2015. Port Lafito is part of the Lafito Global Economic Zone, which is a free economic zone aiming to boost regional and national economic development. The zone and specifically the port are run by GB Group (Gone Native LLC, 2015). There is a large spectrum of different stakeholders: local citizens, employees and the local community expect improvements in living conditions, while international transport companies require as advantageous conditions as possible. The Haitian government is involved in the project realization, which raises the claims for economic benefits.

To measure the Resilience Dividend, GIB focused on the Port international de Port-au-Prince, that is, the hitherto single capital port, as the reference project for Port Lafito. While there is enough data to allow for a comparative analysis at the project level, the data is not enough to produce a SuRe SmartScan for the old Port international de Port-au-Prince. Therefore, some modifications have to be made. The procedure is as follows: the devastating 2010 earthquake in Port-au-Prince is used to assess the Resilience Dividend. The Port international de Port-au-Prince was almost completely destroyed by this disaster. Conclusions about the shortcomings of the port infrastructure's condition reveal the need for improvements in a new port project. Port Lafito, which was partially a response to the earthquake, is analyzed in this sense. Since it is quite new, and no disaster has taken place in this area to date, no judgment can be made as to whether or not Port Lafito will perform better in a catastrophe. However, due to the differences between the two ports, we can estimate Port Lafito's Resilience Dividend.

The main data is provided by the project report of the International Finance Corporation of the World Bank (Gone Native LLC, 2015). It is a principal funder beside of the GB Group. Where additional information is mentioned, the corresponding source is cited.

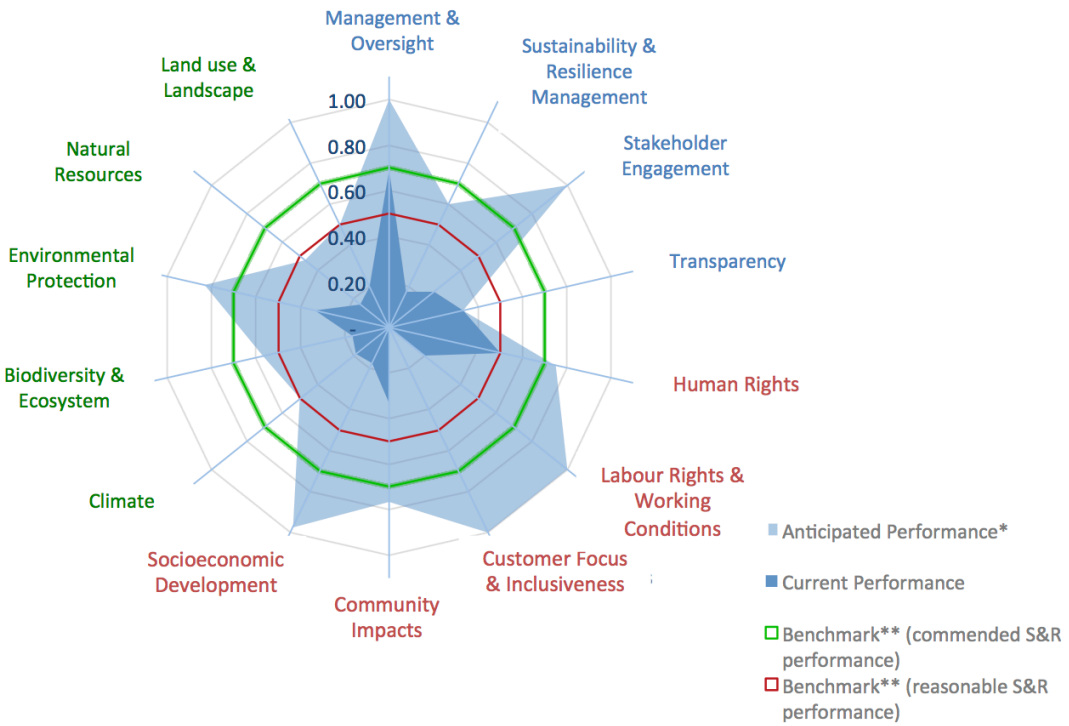
Used data (see references for full citation)

- Environmental and Social Impact Assessment (retrieved from IFC)
- Various academic articles
- Online news articles
- Various stakeholder websites

4.4.2 Resilience level assessment

The SuRe SmartScan of Port Lafito shows an ambiguous result. First, most sustainability and resilience actions are future rather than current practices. This is due to the project report's publication in advance of project realization. While the project is expected to bring numerous social benefits to the Lafiteau community, environmental and governance actions are not exceptional in number and quality.

Figure 9 SuRe SmartScan assessment of the Port Lafito project



Leading

- Located on the coast, an area with lower earthquake risks than in the centre of Port-au-Prince, where the old Port de Port-au-Prince is located (IFC, 2011)
- Health, Safety, Security and Environmental Plan with reporting on key performance indicators
- Employees provided with training on sustainability skills
- Freedom of association and collective bargaining
- Grievance mechanism in place

- Accounting for risks of different kinds:
    - Environmental: hurricanes, earthquakes, floods
    - Social: community health and safety risks
- Focus on local supply chains
- No resettlement
- Social investment and local hiring programs

Commended

- Assessment of environmental, social and economic risks and opportunities
- Sustainability manager appointed
- Public reporting of social and environmental policies
- Commitment to gender equality
- Gender opportunity policy and programs
- Commitment to good and safe working conditions
- Avoidance of discrimination based on age, gender, sexual orientation, health, race
- Ongoing stakeholder engagement throughout implementation phase
- Concrete measures for emergency preparedness:
    - Site specific emergency preparedness and response procedures
    - Spill prevention and control measures
    - Training program for employees
    - Coordination with local authorities
    - Risk assessment of the terminal
- Project located in an area with high poverty and unemployment
- Occupational health and safety guidelines concerning water quality, life, transport and fire safety, hazardous materials, disease prevention and emergency preparedness
- Limited impact on biodiversity due to biodiversity conservation by revegetation of disturbed areas
- Waste management plan compliant with World Bank guidelines
- Monthly air and noise monitoring
- Waste generation minimized

Drawbacks / Room for improvement

- No account of climate change and GHG reduction targets
- Renewable energies and energy efficiency not emphasized
- Resource efficiency not emphasized
- Pure greenfield project

As mentioned, it is not possible to carry out a full SuRe SmartScan analysis for the Port international de Port-au-Prince. However, some information from prior to the devastating earthquake of 2010 is available. A study found that the physical condition of the port was quite poor. For instance, an inspection of the wharf revealed that half of the bents where insufficiently covered by concrete and many piles where destroyed (Green et al., 2011, p. S47). Moreover, the seaport fills were highly susceptible to liquefaction (ibid. p. S60). These are clear indications that the resilience of the Port international de Port-au-Prince was highly insufficient.

4.4.3 Post-disaster assessment

An overview of the disasters in Haiti over the past ten years reveals that they are large in number and most of the catastrophes were the result of floods and storms (hurricanes). Often, the floods were caused by hurricanes.

Table 17 Summary of natural disasters in Haiti 2006 – 2016

Disaster type	Occurrence	Total deaths	Total number of people affected	Total damage in USD ('000)
Drought	2		4,600,000	
Earthquake	1	222,570	3,700,000	8,000,000
Epidemic	6	7,128	585,253	
Flood	26	289	395,345	
Storm	16	1,474	2,769,807	2,254,000

Source: CRED (2017)

Among the many different smaller and larger disasters in Haiti, one overshadows all others and took place in the Port-au-Prince area. As already mentioned above, the Haiti study concentrates on this catastrophe, namely the earthquake that took place in January 2010. Specifically, the study focuses on the performance of the Port international de Port-au-Prince both during and after the earthquake. Since the data available is not sufficient, the port-related indicators are complemented with higher-level data. All in all, the Port international de Port-au-Prince suffered severe damage, which had a far-reaching impact by hampering emergency service deliveries to the affected city population and delaying recovery.

Table 18 Indicators of the earthquake in Port-au-Prince in 2010

Macro and meso Level Indicators[1,2,3,4]	Micro level indicators[5,6]
• Number of people killed: 222,570 • Number of people affected: 3,700,000 • Damage: USD 8 billion • Displaced people: 1.5 million immediately after the earthquake and still about 55,000 in September 2016 • 293,383 houses damaged or destroyed • 1.5 million homeless people • 60% of government and administrative buildings, and 80% of schools destroyed • Cholera outbreaks due to insufficient health supplies	• Extensive liquefaction of north wharf • Large lateral spreading of soil • Cranes and concrete marginal wharf displaced into the bay • Entrance roads damaged • Part of the south pier collapsed • Port unable to receive emergency relief cargos • Efforts to restore shipping deliveries for humanitarian emergency response started only six days later • Reconstructed north wharf only reopened in January 2016

Sources: [1] Natural Catastrophe Database, 2016; [2] CNN Library, 2016; [3] Disaster Emergency Committee, 2016; [4] Basu, 2010; [5] Green et al., 2011, pp. S47–S54); [6] Edward, 2012, pp. 81, 88, 114)

4.4.4 Resilience Dividend

The new Port Lafito has not had to endure a disaster yet. But GIB can identify the shortcomings of the Port international de Port-au-Prince. The SuRe SmartScan shows how far Port Lafito takes these drawbacks into account. Depending on the SuRe SmartScan judgment, we get an indication of whether the losses to human lives

and physical infrastructure can be prevented in the future. This estimate allows us to compare the avoided losses of Port Lafito and Port international de Port-au-Prince respectively, and hence to quantify the Resilience Dividend. The procedure for benefits in a situation without a disaster is analogous.

Assumed avoided losses because of disruption preparedness

Table 19 Expected Resilience Dividend in a disaster case

Dividend	Description
Financial Dividend	• Reduced infrastructure damage, reduced monetary losses (old port's reconstruction costs suggested to be many millions as overall reconstruction costs in Port-au-Prince after the earthquake are estimated to amount to up to USD 14 billion[1]) • Economic gains due to faster reconstruction and recovery of Port-au-Prince • Financial gains for port since operations can go on (the old Port handled 200–250 containers per day[2]; losses can thus be calculated by multiplying them with the number of non-operative days)
Human Dividend	• Human lives saved due to faster emergency relief delivery • Prevention of epidemics thanks to medicine delivery • Reduced or no fatalities and injuries among staff due to training program for employees
Natural Dividend	• No environmental contamination by potentially toxic stored freights
Physical Dividend	• No physical material losses
Political Dividend	• Intactness of port as an infrastructural and economic bottleneck facilitates coordination of reconstruction of the whole area
Social Dividend	• No loss of employment and income of the community when port operation is maintained

Sources: [1] Reuters (2010); [2] K International (2016)

Expected additional Benefits in absence of a disaster (SRBA)

<u>Environmental</u>

- Vegetation / landscaping on and around the site
- Improvements to low head dams in Simonette, a municipality close to Lafiteau

<u>Social</u>

- Improved local skill base

<u>Economic</u>

- Direct and indirect employment opportunities estimated at 25,000 (Port Strategy, 2015)

4.4.5 Interpretation of the Resilience Dividend

As regards the ports in Port-au-Prince, GIB found evidence of a positive Resilience Dividend that is realized over time and assessed as a difference in resilience between the Port international de Port-au-Prince and Port Lafito. While the physical structure of the old port was overwhelmingly poor and indicated a low resilience level, the new port does not have an outstanding resilience performance, but has implemented several crucial improvements. There is progress in port operation governance and in stakeholder engagement. A distinguished characteristic of the project is its focus on emergency preparedness in the form of response procedures, em-

ployee trainings and coordination with local authorities. Crucially, the chosen location means that the infrastructure is better protected from earthquakes and floods. Therefore, the Resilience Dividend materializes in its various components as it can be expected that human lives will be saved and material and financial damages will be prevented in future disasters. Since Port Lafito has not experienced a disaster yet, the Resilience Dividend can only be estimated based on existing data.

While the disaster preparedness component of the Resilience Dividend is clearly identifiable, the assessment of the benefits in times of non-disruption is much less pronounced. The employment prospect is bright. However, other free economic zones in Haiti have shown that promised employment did by far not realize and that working conditions are often precarious (see, for instance, Thomas, 2016). Furthermore, the new Port Lafito project fails to provide a broader emphasis on environmental issues, including climate change and natural resource consumption in particular.

5 Overall Interpretation of the Resilience Dividend Study

Despite data limitations, the four case studies have revealed important aspects of resilience. In this chapter, an overall interpretation discusses whether the approach to resilience measurement can be confirmed and what the main findings are. In addition, it is about what communalities infrastructure projects have with respect to resilience and what the main lessons learned are.

5.1 Comparing the Project Findings

Overall, the applied indicators for disaster and non-disaster scenarios confirm the SuRe SmartScan findings. In order to achieve a synthesized judgment on the case studies, Table 20 outlines defined performance levels (very bad, bad, medium, good, very good, excellent). We see that the projects with a good SuRe SmartScan outcome have a higher degree of disaster preparedness and more additional benefits than those with a bad or medium SuRe SmartScan result. This conclusion is very promising for future work regarding resilience and infrastructure.

Table 20 Summary of the project case study results

	Manila		**Mathbaria**	**Quito**	**Port-au-Prince**
	SLEX	NLEX			
SuRe SmartScan (Overall resilience level assessment)	Good	Very good	Very good	Good	Medium
RD component: Disaster preparedness (avoided losses)	Medium	Medium	Good	Very good	Medium
RD component: Additional benefits (in absence of a disaster)	Medium	Good	Very good	Good	Bad
Overall judgment	Medium - good	Good	Very good	Good	Medium

Source: GIB Foundation

5.2 Overall Interpretation – Communalities and Overlaps

Even though the case studies are quite different in their character, there are several overlaps and common characteristics. By detecting and interpreting them, we gain new insights for future resilience research and policymaking. The first overlap of the infrastructure case findings clearly indicates that these critical infrastructure projects play a crucial role in the overall well-being of a countries' economy. In the case of the airport in Quito, Ecuador, the major part of the import and export economy relies on the functioning of the airport. Similar to the airport, the NLEX expressway in Manila and the port in Port-au-Prince are important for the smooth transition of goods and services from and to the customer.

The involvement of all stakeholders in the projects of Manila (NLEX), Quito, and Mathbaria (Bangladesh) proved to be very effective, as indicated by the SuRe SmartScan. According to various sources, the overall acceptance of these projects was higher than in Port-au-Prince, for example. In other words, if all stakeholders

are involved, the infrastructure project is more widely accepted, which results in a better overall resilience level.

Infrastructure projects that have been completed more recently have a larger focus on resilience and sustainability than older projects. There is a clear trend that resilience and sustainability plays a more prominent role in the thinking of upcoming infrastructure projects financed by MDBs. The most recent of the projects examined, the coastal town project in Mathbaria, includes the most resilience planning in its thinking. The goal now is to promote this kind of thinking in the next decades to come.

When the focus of an assessment is on ESG topics, it is often because the project owner has carried out an environmental impact assessment (EIA). Sometimes, in the case of Quito for example, an environmental and social impact assessment (ESIA) is carried out. The focus of project owners on ESG criteria is preliminarily on the environmental part. The social part is only sometimes covered, and only assesses the amount of people affected. The third component, the governmental part, is often not looked at to the same extent as the other two.

The Financial Dividend in the non-disaster component of the Resilience Dividend is not easy to calculate and quantify in USD terms. In the case of an infrastructure project, future quantification could be done in the following way: for example, Quito airport has a certain number of daily flights that provide information on the number of people transported and the amount of goods imported and exported. Therefore, the indicator could detect how long the airport is not running properly, while the monetary loss can be calculated by multiplying the indicator value by the daily financial turnover at the airport.

Another point to be emphasized is the fact that the avoided losses are not as visible as the additional benefits. These two parts of the Resilience Dividend clearly play a different role when planning an infrastructure project. Additional benefits will positively affect the society, the economy, and the environment right after the project's completion. On the other hand, avoided losses only come into play when there has been a disaster, which can of course come in all shapes and sizes and can occur at any time. Therefore, the sales pitch for developers, authorities and investors to invest in a certain resilience measure is quite critical because one benefit will come right away, and the other only in the future. However, there will always be doubt concerning which benefit is more important. In other words, long-term thinking about risk and opportunities has to be considered in every infrastructure project.

Other major points for discussion are the trade-offs and the sustainability costs within infrastructure projects. In the planning and execution of an infrastructure project, trade-offs are commonplace. The project owner has to decide which features the infrastructure will have and who will be affected or benefit from it. For example, a question could ask whether the new airport in Quito is better because there is less traffic in the city center or whether the airport is worse because it was built in a greenfield zone. The new airport in Quito also affects new neighborhoods because of the relocation of this important transport hub. Or, in the case of Port-au-Prince, is saving the work of traditional fishermen more important than having a port in a less disaster-prone area? The new port increases the noise pollution in the neighborhood and sedimentation in seagrass beds. In other words, every infrastructure project has sustainability costs as well as benefits. As a result, trade-offs will always be a part of infrastructure projects, which can be seen in all the case studies examined. It is unlikely that any one approach will be able to dissolve this trade-off. This is valid for the SuRe SmartScan, too. However, while the GIB methodology cannot make the trade-off vanish, it can optimize it.

Similarities between the assessed infrastructure projects also included the lack of adherence to long-term climate thinking. The example of the Panama Canal in section 2.3 highlighted that long-term thinking (> 20 years) must be taken into account in the planning of critical infrastructure. Only the newest infrastructure project of the coastal town Mathbaria took the IPCC climate change scenarios into account. In general, infrastructure

projects are built to last almost a lifetime and therefore, long-term thinking in ESG has to be a major planning point.

The last overlap between the four infrastructure cases is the lack of transparency within the whole infrastructure life cycle. In the design and construction phase, there are signs of transparency and inclusion of the affected communities. However, all four projects lack data on topics like human rights, political participation, and corruption. It is also uncommon for impact assessments to be carried out in a transparent way once an infrastructure project has been finalized. Some MDBs are about to start with periodic assessments, which are publicly available.

5.3 Lessons Learned

The next few paragraphs contain some insights into the lessons learned during this study, which set out to identify and measure the Resilience Dividend. First, the Resilience Dividend does exist, and investments or inputs in resilience do pay off. The four infrastructure case studies clearly demonstrate that there is a Resilience Dividend in the case of a disaster or even without; and this is true even in the event of insufficient data. Future research is needed, and a solution to the lack of data is presented in the next chapter. One can also say that the more resilience measures are taken, the larger the associated benefits will be.

Second, the concept behind resilience is multidimensional and interdisciplinary. If one wants to measure and quantify the Resilience Dividend, one has to assess resilience in a standardized way, repeatedly and over a long period of time. Presumably, our research partners at the RAND Corporation have achieved this insight as well. “Resilience” is a huge concept, meaning that partnerships with different backgrounds and sectors will be necessary to tackle the issue of not being resilient.

Third, and the most important questions to ask in terms of resilience: ‘resilience for whom and resilience to what?’. Before assessing resilience, one has to ask these questions. It is crucial that all stakeholders provide answers in this regard so that eventual trade-offs can be reduced. GIB’s approach to resilience focuses on resilience and sustainability in the (ESG) infrastructure assessment. This naturally has limitations, as previously explained. However, critical infrastructure plays an important role in a country’s economy and in the well-being of its citizens.

Fourth, there are sustainability costs and trade-offs in the infrastructure sector – as presented above. Hence, the Resilience Dividend does not equally benefit all stakeholders; some might even experience negative effects. This has to be kept in mind when measuring the Resilience Dividend for a specific group of people. The RAND Corporation has similar conclusions regarding this point.

The fifth point relates to the insufficient data to prove and/or value the Resilience Dividend. In the same manner, closing the sustainable and resilient infrastructure investment gap requires compelling risk-return data. Data is needed regarding returns on investment for resilience measures and for the correlation between the ESG and economic/financial performance of infrastructure projects. This data will help to make resilient and sustainable solutions more attractive to investors, developers, and public authorities.

In addition, decision makers and other stakeholders need additional insights into the concept of resilience. At the moment, the SuRe SmartScan gives infrastructure decision makers the option to compare two projects regarding the ESG costs and benefits at a certain point in time. For example, the decision makers of the New Quito Airport could have assessed the old and the new airport with the SuRe SmartScan to get an idea of which airport is more resilient and sustainable.

Finally, the resilience of individual infrastructure projects is key to the overall disruption preparedness (avoiding losses) and the value-adding benefits in a certain neighborhood, city or country. In other words, when in-

frastructure is better prepared for disasters, the community will experience a higher Resilience Dividend in terms of value-adding benefits and in the event of a disaster when losses are avoided.

5.4 What Is Missing?

As indicated under the lessons learned above, resilience is a multi-faceted and highly dynamic animal that is difficult to catch. In order to capture it, the authors of this study found that the following elements are missing:

1) An easy-to use tool that captures the complex and evolving nature of resilience as widely as possible, e.g. that goes beyond the scope of the SuRe SmartScan. The SuRe SmartScan is a tool for practical project development, while the new tool will in addition be dedicated also to resilience research and the accumulation of new conceptional and empirical insights. While aligning existing resilience languages, definitions and taxonomies, such a tool should serve the needs of everyone already concerned about assessing, fostering and measuring resilience. This tool should likewise serve as a checklist providing an answer to the question: “What data do we need in order to validate resilience?”

2) Resilience awareness trainings for those unaware of resilience benefits and not yet concerned about fostering, measuring and enhancing resilience. Such trainings should provide answers to the question: “Why should we implement resilience and collect data for its validation?”

3) Resilience implementation trainings on the ground that go beyond awareness raising and help to deeply root resilience thinking and behavior among actors in the infrastructure sector – especially for multiple disadvantaged groups. Resilience implementation trainings should provide an answer to the question: “How, where and when should we collect data?”

4) A registry containing the collected data and serving as a source to prove the existence and the validation of the Resilience Dividend across sectors and countries. Such a registry should address the question: “How can we store and evaluate data for the best possible use in the future?

6 Outlook

The final chapter of this study provides a theory of change as well as a derived possible approach on how to prove the existence of the Resilience Dividend more efficiently and with more precision in future. The logic behind the attempts introduced below is deeply rooted in GIB's thinking on what is missing: Today, actors in infrastructure lack easy-to-use tools, resilience awareness as well as the technical expertise needed in order to implement resilience aspects right at the beginning of every infrastructure project's life cyle. In addition, meaningful data is rarely collected. Currently available resilience data is either completely missing or inadequate, which prevents many institutional investors from financing resilient and sustainable infrastructure.

6.1 Theory of Change

A theory of change is more than a logical framework about activities, outcomes, outputs and goals because it not only details what is linked, but also how something is linked. In our fast-paced, ever-changing world, new knowledge, additional insights and new theories are emerging in high numbers, hence the development of any theory of change will also be subject to change and thus rather time consuming.

Accordingly, Figure 11 below demonstrates how GIB's current theory of change will need to be adjusted over time as well. The interconnectivity of the several steps mentioned today might be mapped differently or change completely in future.

In line with the GIB Foundation's mission, the four anticipated activity streams focusing on:

1) Tools;

2) Capacity building;

3) Technical assistance (TA); and

4) A project registry

will ultimately lead to one common goal: "resilient and sustainable infrastructure as the new normal".

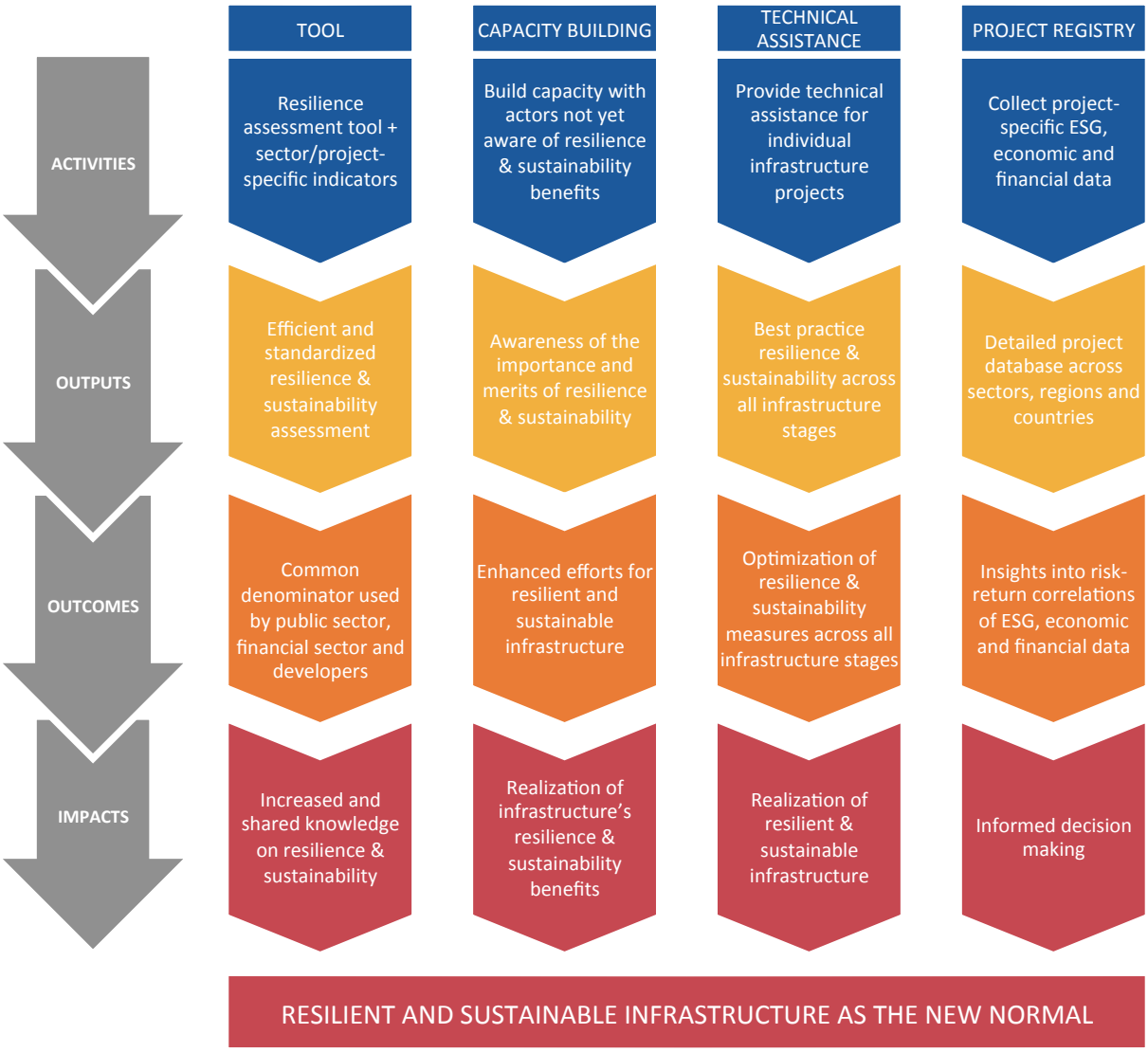
The achievement of this goal will provide the resilience-associated benefits of infrastructure to society in times of disruptions and times without disruptions. In addition, the four depicted streams of activity will be the means to overcome the above-mentioned obstacles to measuring the Resilience Dividend: unsatisfactory tools, insufficient capacity, knowledge and technical assistance as well as missing or inadequate data.

Given the prospect that most of the future infrastructure needs have to be satisfied with infrastructure that has not yet been built, incorporating the financial sector and addressing its respective needs along the entire financial value chain will be decisive. The make-or-break point in reaching the ultimate goal of "resilient and sustainable infrastructure as the new normal" will be the ability to demonstrate the merits of such infrastructure. Given the classic characteristics of any infrastructure, i.e. asset heaviness, its long-term nature, specific location and rather illiquid investment characteristics, one might intuitively understand that consideration of and adherence to resilience and sustainability aspects will bear fruit over time. However, in order to "unlock the trillions" of Dollars needed to satisfy future infrastructure demands, hard numerical facts are indispensable. Likewise, a different approach and understanding of risk is also needed. To this end, and right on the interface between infrastructure resilience and sustainability assessment and finance, appropriate products have to be developed that provide additional insights into the risks and opportunities of infrastructure investments from a resilience and sustainability perspective. Once the proof for the superiority of resilient and sustainable infrastructure is at hand, and all decisive players along the financial value-chain use tools based on the same

resilience language, definition and taxonomy, a "Resilient and Sustainable Infrastructure Asset Class" – a new asset class blending the characteristics of all types of existing asset classes – might emerge. The number of international actors sharing the vision of such a new asset class is ever increasing.

Please note that, in the following, "outputs" are regarded as short-term, "outcomes" as medium-term, and "impacts" as long-term achievements.

Figure 10 Theory of Change (GIB)



Source: GIB Foundation

6.2 Tool

As depicted above, an easy-to-use tool should be designed that:

1) Indicates what to look at in order to achieve and validate resilience;

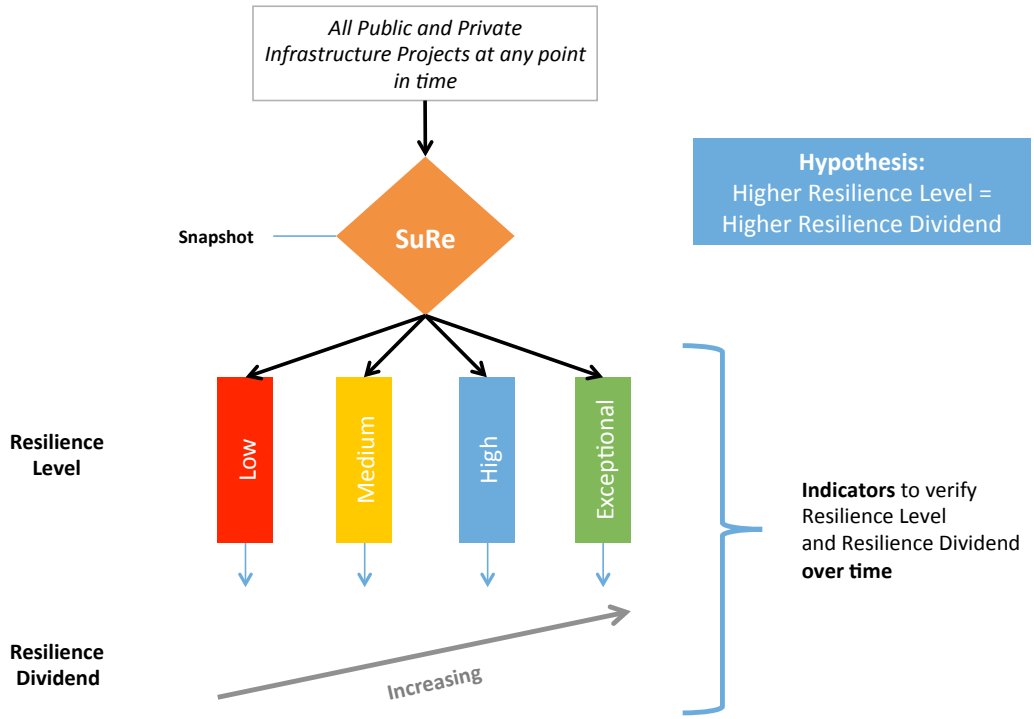
2) Provides a snapshot resilience level assessment at one point in time against which to benchmark the subsequent resilience and ESG-performance of any project in predefined cycles or after certain events have taken place;

3) Provides a set of sector- and, where applicable, region-specific indicators for testing and valuing the Resilience Dividend;

4) Is informed by the work of others and thus incorporates the findings of the current study and other existing knowledge on resilience.

The Figure below shows the specific theory of change behind GIB's activity stream number 1 depicted above, i.e. "Tool".

Figure 11 Theory of Change for the "Tool" (GIB)



Source: GIB Foundation

This theory of change is based on the hypothesis that the level of resilience assessed at *one point in time* (a snapshot) will *over time* lead to a corresponding Resilience Dividend: if an infrastructure project meets no or only very few SuRe® criteria at low levels (see section 3.2.2), a low Resilience Dividend is expected. In contrast, projects meeting all criteria at the highest level will indicate an exceptionally high Resilience Dividend.

In order to further prove this assumption beyond the featured case studies, GIB suggests assessing public and private infrastructure projects using its SuRe® criteria. Such snapshot assessments will subsequently serve as a benchmark against which the resilience and sustainability performance of the given project has to be conducted using infrastructure sector-specific indicators in predefined cycles, or after certain events have taken place such as disasters or refurbishments of a particular infrastructure. The repetition of these snapshot assessments, with the subsequent comparison of "real-world data" such as economic and financial performance data over time, will not only lead to the proof of corresponding correlations needed in order to "unlock the trillions", but also to the refinement of the tool used. Through this, users will eventually be able to identify resili-

ence and sustainability benefits with a high degree of probability. In other words, "this level of resilience will yield that specific benefit". Accordingly, informed (investment) decisions on future infrastructure projects will take place and thereby make resilient and sustainable infrastructure the new normal.

In developing such a tool, the enhancement and/or alignment of existing tools and concepts is necessary,[9] as is the incorporation of a diverse range of stakeholders. In fact, the combination of multi-stakeholder knowledge and the alignment of different actors towards a shared and agreed resilience language, definition and taxonomy will be key for the success of such a tool.

With such a tool at hand, an efficient, reliable and standardized assessment and eventual validation of the Resilience Dividend will become possible. This will in turn serve as a common denominator for the most decisive players in any infrastructure project, i.e. representatives from the public sector, financial sector and developers. The thus achieved increase and shared knowledge on resilience and sustainability of all infrastructure actors will be the decisive step to rooting resilience in the design, planning, construction, operation and finally decommissioning phase of any infrastructure project. In addition, such a tool will include and align city and project management-specific requirements and pave the way to assessing resilience beyond a project perspective. Ideally this tool will come in a set, with a handbook that not only explains its usage but also shows how to conduct effective and inclusive capacity building for diverse audiences.

6.3 Capacity Building

As seen in the SuRe® pilot phase examples mentioned above in Chapter 3, carefully designed capacity building programs are highly sought-after. Building the capacity of actors not yet aware of resilience and sustainability benefits is an utmost priority. All too often, those prone to disruptions and stresses have insufficient knowledge about avoidance of losses and how to better their lives.

Every meaningful capacity building program focuses first on general awareness raising while taking existing levels of knowledge into account and, second, on project-specific on-location trainings serving the development needs of the respective stakeholder group. It is decisive to generate a consistent and coherent understanding of what resilience and sustainability are, and what benefits come attached to them. Once an understanding of these benefits is achieved, the efforts to increase the resilience and sustainability of infrastructure are usually increased by the actors involved. At this stage, capacity building programs aim to answer the question concerning how to implement sustainability and resilience aspects in the planning, design, procurement, construction, operation and decommissioning phase of any infrastructure project. Equally, the question is addressed concerning how to collect meaningful data for a subsequent evaluation of whether the measures taken are bearing fruit.

A capacity building program should incorporate an easy-to-use tool, as outlined above. It is also important for the capacity building program to incorporate state-of-the-art knowledge from a huge variety of infrastructure stakeholders as well as current international best practices for participatory knowledge sharing.

[9] GIB for instance is collaborating with Quantis International in order to link the SuRe® criteria to the valuation standards of the Natural Capital Protocol (NCP) and the Social Return On Investment (SROI). This allows the measurement and valuation of the total impact of a SuRe® infrastructure project. Both, negative and positive impacts will be accounted for along the social, environment and governance themes, together with the subsequent economic impacts that these lead to. The impact on the ecosystem services and on the social system will both be measured in monetary units what allows a full integration in the financial profit and loss assessment of an infrastructure project. This Natural and Social Capital Valuation allows the comparison of the impacts and benefits of the three pillars of sustainability, i.e. environment, society and governance. Furthermore, it allows the detection and mitigation of critical risks in an early stage of project planning.

GIB's examples from India show that tailored workshops with public officials in the area of master planning, public procurement and public private partnership (PPP) design, as well as with financial institutions and construction companies on respective topics, lead to favorable outputs. One key outcome for the project in India was an increased awareness of climate change scenarios that might impact the project and others in the same development program. Subsequent "train the trainers" sessions helped to ensure that the know-how achieved could be kept in the location – as did the franchising with local capacity building organizations.

6.4 Technical Assistance

Technical Assistance (TA) goes one step further than capacity building by focusing on the entire value-chain of an individual infrastructure project, and usually spans a much longer time period. TA is of particular importance in settings where actors are not sufficiently aware of best practice resilience and sustainability approaches. It helps to implement resilience and sustainability right from the beginning of any infrastructure project and thus to optimize adherence to these practices throughout its entire life span.

Typically, TA starts with advice on how to conduct technical, economic and social (pre-) feasibility studies. Subsequently, assistance on compiling and implementing a business plan and on developing a financing strategy is given, usually followed by support on development of these plans and strategies. In addition, technology assessments and evaluations, as well as resilience and sustainability assessments are conducted.

Based on this, localized multi-stakeholder processes are defined and designed – usually from two angles: bottom-up and top-down. The bottom-up approach includes diverse forms of analysis like a multi-stakeholder needs assessments based on qualitative and/or quantitative surveys, key informant interviews, etc., whereas top-down evaluations also comprise contextual analysis, taking into account diverse affected policies and target groups, for instance urban planning, land use rights, economic and social policies. Naturally, subsequent synthesis and gap-analysis between bottom-up and top-down results takes place in close collaboration with local partners. Once processes are in place or launched respectively, on-site observations and an appropriate mapping of the current status takes place to contrast the planning with future developments of infrastructure and society. This data collection process is especially important in areas prone to natural disasters, and allows for adjustments to the respective activities in every phase of the infrastructure life span.

6.5 Registry

Whereas a resilience assessment tool, in combination with sector/project-specific indicators clarifies what to look at when implementing resilience, Capacity Building and Technical Assistance raise resilience awareness and pave the way for the collection of data along the entire infrastructure value chain over its life cycle. A registry for infrastructure project-specific data finally serves as the ultimate "collecting tank" for this data. The smooth and multi-stakeholder backed interaction of all four activity streams – the tool, capacity building, technical assistance and the project registry – is decisive and represents a compelling way to achieve the goal of resilient and sustainable infrastructure becoming the new normal, and the attached benefits.

A project registry would contain infrastructure project-specific resilience, sustainability, economic and financial data across sectors, regions and countries in order to provide insights into risk-return parameters and the correlations of ESG, economic and financial data and eventually allow best informed decision making. Compiling such a project registry is a huge endeavor that would require the close cooperation of diverse actors over a long period of time. The above-mentioned importance of a common resilience language, definition and taxonomy therefore becomes even stronger.

GIB considers that four steps are necessary for the implementation of a project registry:

1) An analysis of the current global infrastructure situation with regard to sectors, regions, countries and its development over the last ten years in order to define the range of projects that should be contained in the registry.
2) Further teaming-up with reliant and well-connected players[10] in the infrastructure field to create personal ties and trust in order to gain access to hitherto not publicly available data. The close co-operation with a research institute specializing in infrastructure risk will help to further define the range of data to be collected.
3) Establishment of organizational structures guaranteeing anonymity of entrusted data.
4) Development of a mathematical model in cooperation with a suitable partner in order to compute correlations between resilience and sustainability performance as well as financial and economic performance.

Depending on the data quality and feasibility, a retrospective analysis ("ex post") of correlations between resilience and sustainability performance with economic and financial performance may be conducted. A forward looking analysis ("ex ante"), building on the work done in the current study and informed by the work of other actors in the field of resilience research shall also be conducted. Either way, the proof that resilient and sustainable infrastructure is a first choice and a decisive step to achieving overall resilience for the entire society – in times of disruptions and times without disruptions – will be decisive to unlock the financial flows needed to achieve this goal.

[10] ICLEI, C40, R20, CCFLA, Global Green Growth Forum (3GF)

7 Conclusion

This study has tested the hypothesis that resilience measures in infrastructure projects pay off. The pay-off stemming from resilience measures taken and materializing irrespective of a disaster can be referred to as the Resilience Dividend. By applying GIB's methodology – a combination of a practical one-point in time assessment serving as benchmark for the following application of infrastructure-specific indicators over time – to four concrete infrastructure projects in different cities around the world, this study has indeed revealed that a higher resilience level gives rise to many benefits of different kinds. Some of these benefits are revealed when a disaster occurs, while others materialize even in times of no disruption. In some projects, the benefits are obvious and have been revealed by disasters that have taken place since project realization. In others, as in Mathbaria and partially in Port-au-Prince, the benefits have to be estimated because either the project has not yet been completely realized or has not yet experienced disasters – the result in such cases is an 'expected' Resilience Dividend.

Applying the practical SuRe SmartScan to assess the resilience level at a certain point in time and relating it to the resulting benefits via an indicator-based measurement including, among others, the SRBA, has proved to be a useful and promising approach. Besides the Resilience Dividend itself, this study has found additional insights for future project development as well as for future research. The projects examined have revealed that any infrastructure project faces trade-offs with respect to resilience and sustainability. For example, there may be a trade-off between economic benefits in the form of increased employment and the additional consumption of greenfield areas caused by the project. Here, the SuRe SmartScan helps to judge and optimize the trade-offs, that is, to minimize negative impacts while maximizing the benefits.

Resilience is a multidimensional issue. It contains, among others, many different financial, social and environmental aspects. By taking account of resilience in all its dimensions, it is not possible for such a study to provide a final result in the form of a single monetary value. Measurement results remain multidimensional just like the real world we live in. Given that our suggested approach simplifies, quantifies and allows for comparability, we defend its multidimensional character. It may not be the simplest approach, but it is likely to be the only way to get a true and deep idea of resilience.

The main lesson learned from this study is that much more resilience research is needed. This contribution should not be seen as final, but rather as the starting point for further and deeper resilience research. Missing data will be the most significant obstacle in this regard. While the SuRe SmartScan can be applied in practical project development, further steps are needed in order to deepen research and support future infrastructure resilience planning: capacity building to foster resilience awareness, technical assistance on the ground to help implement resilience – especially in areas with limited knowledge – as well as an easy-to-use tool comprising advice on what to look at when thinking about resilience and provide a benchmark against which to compare, and indicators with which to measure will help to ensure a more resilient world for everyone. The data collected during these steps should feed into a comprehensive registry that will yield more knowledge and help to make resilience, together with sustainability, a must-have for infrastructure investors, project developers and policy makers.

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Appendix

SuRe Standard Committee Members

Name	Organisation	Stakeholder Group
Peter Boswell	International Federation of Consulting Engineers (FIDIC)	Project Developers
Loa Buchli	Federal Office for the Environment (FOEN)	Public Sector
Alejandro Eder *(Caicedo Pérez, Mariana)*	Fundación para el Desarrollo Integral del Pacífico (FDI - GIP)	NGO
Hervé Guez *(Emmanuelle Ostiari)*	Mirova	Finance
Zoran Jelic	Community Realization European Aid Masterplan (C.R.E.A.M) Europe	Others
Stefanie Lindenberg	European Investment Bank (EIB)	Finance
Ana Marques	ICLEI - Local Governments for Sustainability	NGO
Britta Rendlen	WWF Switzerland	NGO
Palash Srivastava	Infrastructure Development Finance Company (IDFC)	Finance
Davide Stronati	Mott MacDonald	Others
Rainer Zah	Quantis Zürich	Others
Ruijie Zhang	China Association of Plant Engineering Consultants (CAPEC)	Project Developers
Madeleine Varkay	Asia Pacific Financial Forum	Finance
Marie-Luce Godinot	Bouygues Construction	Project Developers
Katharina Schneider-Roos	GIB	SuRe® Secretariat

Global Infrastructure Basel

SuRe Stakeholder Council Members

Name	Organization	Categorization
Alexandrino Diogenes	City of Fortaleza	Public Sector
Anne Maassen	World Resources Institute (WIR) Ross Centre	Civil Society
Archana Hingorani	Infrastructure and Leasing & Financial Services (IL&FS)	Developers & Contractors
Blake Robinson	Sustainability Institute	Academia
Camille Maclet	Environmental Resources Management (ERM)	Certifiers & Consultants
Caroline Huwiler	Institute for Development, Environment and Energy (IDE-E)	Civil Society
Cedric Grant	City of New Orleans	Public Sector
Dario Liguti	General Electric	Developers & Contractors
Dean Alborough	African Infrastructure Investors Managers (AIIM)	Financial Services
Dorah Nteo	City of Tshwane (South Africa)	Public Sector
Dorothée Allain-Dupre	Organization for Economic Co-operation and Development (OECD)	Others
Enrico Vink	International Federation of Consulting Engineers (FIDIC)	Developers & Contractors
Inga Beie	GIZ (Gesellschaft für Internationale Zusammenarbeit)	Others
Jason Zhengrong Lu	Global Infrastructure Facility (WB)	Financial Services
Jean-Pierre Méan	MCE Legal Avocats	Civil Society
Jörg Rüedi	Pöyry Switzerland	Developers and Contractors
Katrin Hauser	Climate-KIC Switzerland	Civil Society
Linda Krueger	The Nature Conservancy	Civil Society
Mischa Lentz	European Bank for Reconstruction and Development (EBRD)	Financial Services
Nikolaj Gilbert	United Nations Office for Project Services	Civil Society
Oliver Greenfield	Green Economy Coalition	Civil Society
Dr. Renard Siew	Sime Darby	Developers and Contractors
Robert Kehew	UN Habitat	Others
Prof. Shuaib Lwasa	Makerere University (Uganda)	Academia
Suhail Hajee	Arqaam Capital	Financial Services
Silvio Leonardi	True&fair.expert	Certifiers and Consultants
Travis Sheehan	City of Boston	Public Sector
Timothy Geer	WWF International	Civil Society
Vanessa Otto-Mentz	Santam	Financial Services
Xiaomei Tan	Global Environmental Facility (GEF)	Financial Services