
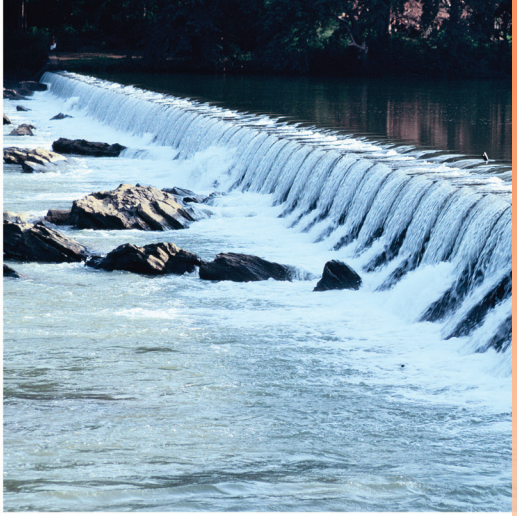

Enabling Environment for Private Sector Adaptation

An Index Assessment Framework

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IFC International Finance Corporation
World Bank Group

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Acknowledgements

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Preface

The Group of 20 (G20) nations increasingly recognize the importance of green growth, and many countries are demonstrating strong leadership through effective and progressive policies. However, governments do not act alone—the private sector is an important partner, providing new technologies, business models and investment opportunities across a variety of sectors to help scale up transformation. In 2012 the G20 Development Working Group commissioned the International Finance Corporation, as the largest development finance institution dedicated to private sector development with a strong emphasis on sustainability, to take stock of mechanisms to mobilize private capital, including from institutional investors, for inclusive green growth investments in developing countries. This work is intended to inform the creation of a public-private G20 Dialogue Platform on Inclusive Green Investment.

As part of this effort IFC commissioned a series of supporting documents and materials, including this publication, specifically created as underpinning material to inform the final synthesis report produced by IFC for consideration at the G20 meeting in St. Petersburg in 2013. These publications can all be found at www.ifc.org/Report-MobilizingGreenInvestment.

1 Introduction

Over the past years dramatic changes in climate patterns have been observed and extreme weather conditions have been experienced around the world: record temperatures, destructive floods and tropical cyclones, dramatic droughts, and raging wildfires. There is much evidence showing that climate change is partly responsible for these trends. Overall, it is middle- and low-income countries that experience greatest losses from a changing climate due to generally greater climate vulnerability of their socio-economic systems.

Climate change threatens to set back the inclusive green growth goals if climate resilience is not an integral part of development plans and investments in both public and private sectors. Conversely, climate resilient growth and adaptation investments are paths that contribute to shared value creation and long-term sustainable growth. Implemented appropriately, adaptation investments can avoid costly losses and reduce social vulnerabilities, promote job creation, and produce 'win-win' opportunities in other climate and green growth areas.

However, private sector—particularly the more vulnerable small and medium enterprises and smallholders, which account for largest share of employment—often face significant barriers preventing the integration of climate change adaptation in planning and operations. The barriers are diverse, ranging from lack of information about climate risks and opportunities, to policies that don't encourage adaptation or even promote actions that increase climate change vulnerability, to lack of incentives for adaptation investments. This leads to business environments that are unfavorable to climate change adaptation, that create sub-efficient markets, and place in peril longer term financial stability and job creation. In contrast, policy, regulation and markets that appropriately incorporate climate change information can create environments that stimulate financial, environmental and social sustainability in the private sector, through increased resilience and the provision of adaptation solutions for the overall society.

This report reviews practical and implementable interventions that have significant potential for the creation of an enabling environment for private sector adaptation and the promotion of climate resilient development paths. While there is a broad spectrum of conditions favorable to climate change adaptation, five priority areas are highlighted in this report: Data and information, Institutional arrangements, Policies, Economic incentives, and Communication, technology and knowledge.

In each of these areas, specific interventions capable of promoting private sector adaptation are analyzed, with an emphasis on their expected economic, social and environmental returns. Measures, indicators and examples are also provided to inform private sector organizations and policy makers about where conditions for adaptation investment are favorable, and what specific improvements can enhance a country's environment for attracting private investment in climate change adaptation.

This initial set of measures and indicators is applied to three countries in an effort to demonstrate how country environments influence the uptake and level of climate change adaptation in the private sector.

Acknowledging that further work needs to be done to develop detailed guidance and indices for objective evaluation of levels of the enabling environment for adaptation, this study aims to produce initial indicators for systematic support of climate resilient development in the private sector context

2 Executive Summary

With escalating weather-related loss and damage, and data improvements, the imperative to adapt to more extreme weather and climate change is steadily being recognized by private sector organizations across the world. As proof, 90% of companies in the Standard & Poor's Global 100 market index have identified present or future business risks associated with climate-related hazards in their financial and non-financial reports. In many developing countries, high exposure to climate-related hazards and existing socio-economic development challenges accentuate climate change vulnerability. Small- and medium-sized enterprises and smallholders are particularly vulnerable and stand to win the most from taking action on climate change. The opportunities of promoting inclusive green growth for these private sector actors through climate change adaptation, from improved access to water or food security to creation of sustainable community livelihoods, are numerous. For instance, research by the United Kingdom has been estimated that by 2020 climate change adaptation goods and services could be worth US$186 billion worldwide. Yet, little is known about the magnitude of climate change adaptation efforts and investment levels in the private sector.

At the global level, commitments have been made to make US$100 billion available each year by 2020 onward to fund actions that reduce greenhouse gas emissions and build climate change resilience in developing countries. Governments have repeatedly confirmed that the private sector has a considerable role to play in delivering part of this funding, especially in today's constrained fiscal environment.

One of the greatest challenges for governments, international organizations and communities consists in implementing successful strategies that engage the private sector—across economic sectors and world regions—to take action and mobilize resources for climate change resilience. However, there is very little knowledge of progress to date and where improvements in country enabling environments are needed to enhance private sector adaptation. In an effort to inform such strategies, this report presents an Index Framework that assesses at a country level whether favorable conditions are in place for climate change adaptation in the private sector.

A review of climate change adaptation drivers and barriers based on existing literature, together with IFC's field observations of private sector needs and motivations and consultations with six companies, informed the definition of the following set of sixteen indicators and measures. This analysis has found that short of one single 'silver bullet', five areas need to be considered in an integrated manner to successfully enhance private sector adaptation, namely: data and information, institutional arrangements, policies, economic incentives, and communication, technology and knowledge.

In an effort to clarify the business case for putting in place mechanisms that enable/incentivize and/or remove barriers to climate change adaptation in the private sector, information on costs and benefits has been provided when

Data and information	**Economic incentives**
1. Climate and hydrological projections	11. Government incentives
2. Direct and indirect impacts	12. Finance
3. Adaptation measures, costs and benefits	13. Full-cost accounting for water and energy
4. Community vulnerability, risk and adaptation	14. Environmental trading markets
Institutional arrangements	**Communication, technology and knowledge**
5. Institutions and forums	15. Information and communication technologies
Policies	16. Technology and knowledge
6. Building standards and/or codes	
7. Public infrastructure	
8. Local zoning rules	
9. Permitting and impact assessments	
10. Investor relations and/or stakeholder management	

available. Contrary to beliefs that there is too much uncertainty to know whether it is financially-sound to adapt, this report includes many examples that demonstrate positive returns on investment, for instance of actions to improve climate and hydrological projections, create institutions or forums to do adaptation research or exchange best practices, or incorporate adaptation considerations in public infrastructure design and operation.

The Index Framework is applied to three countries with different levels of income. Challenges in assessing enabling environments for private sector adaptation exist where information on policies and economic incentives is missing or is of difficult access. This ground-truthing of the Index Framework has shown that country performance is not always uniform across the five areas important to private sector adaptation and levels of country income and development are not good measures of favorable conditions for adaptation.

The approach in this Index Framework demonstrates the value of going beyond raising awareness in the private sector by taking a closer look at what conditions enable/incentivize and create barriers to adaptation actions. It can be leveraged to identify areas in a country where important climate change adaptation drivers are missing or barriers to action remain, assess policies or initiatives that may have conflicting impacts on the private sector and, in general, inform where government, donors and investment organizations should focus their efforts to increase private sector involvement in climate change adaptation.

3 Scope and Approach

This report seeks to define what important conditions need to be in place at a country-level to promote climate change adaptation in the private sector, and how to assess the level of the enabling environment favorable to private sector adaptation in a given country.

While it is acknowledged that virtually all private sector actors, irrespective of sector, size, location, products and services, will be affected by a changing climate, the examples provided in this report are applicable firstly to the key sectors, such as agriculture, power/water utility sectors and manufacturing, but also relevant to other sectors. This is in recognition of the fact that these sectors have a considerable number of private sector opportunities for *inclusive* green growth: from improving access to water and water quality, to increasing food security or creating opportunities to support sustainable community livelihoods.[1] Further, as part of the International Development Agency 16th replenishment, the World Bank singled out agriculture, water and infrastructure as priority sectors in the world's poorest countries where climate change adaptation investments are needed to reduce vulnerability and ensure long-term development and growth.

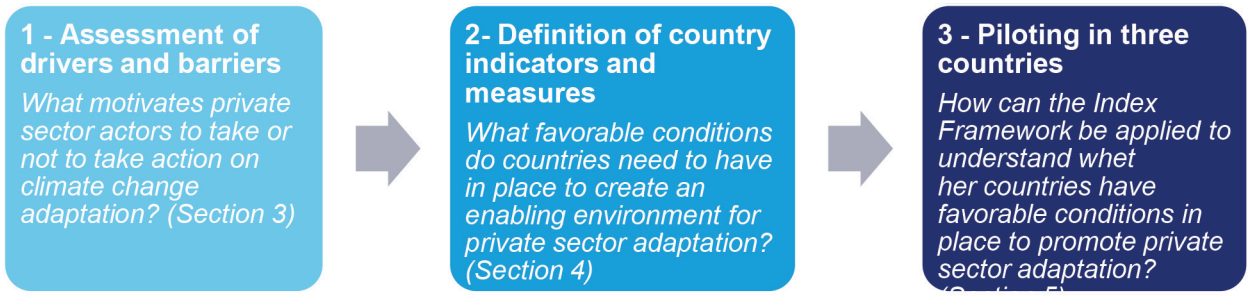
To develop a meaningful Index Framework, three sequential activities were carried out:

1. Assessment of drivers and barriers to climate change adaptation in the private sector;
2. Definition of country indices and measures; and
3. Piloting of the Index Framework in three countries.

Assessment of Drivers and Barriers to Climate Change Adaptation in the Private Sector

Drivers of climate change adaptation are factors that promote, enable and/or incentivize action by the private sector. *Barriers*, on the other hand, discourage/raise obstacles to

FIGURE 1: Overview of the Sequential Process To Develop the Index Framework



climate change adaptation decision-making and implementation, which in turn make private sector adaptation less opportune, efficient and/or effective, or may require costly changes. Barriers lead to missed opportunities to generate revenues from emerging business opportunities or avoid escalating costs due to climate-related impacts.[2] Identifying these drivers and barriers requires:

- Defining what constitutes adaptation in the private sector; and
- Understanding the process through which the private sector makes decisions about whether and how to invest in climate change adaptation.

In an effort to understand the landscape of actions that private sector actors can take to adapt to climate change, a compendium of climate change adaptation actions in the private sector was considered.

Five areas have been identified to play a decisive role in private sector adaptation, namely:

- Data and information;
- Institutional arrangements;
- Policies;
- Economic incentives; and
- Communication, technology and knowledge.

Across these five areas, important drivers and barriers have been identified for each type of private sector adaptation action.

Section 3 of this report summarizes the results of this assessment of drivers and barriers to private sector adaptation. This subsequently informed the choice of indicators and measures for the Index Framework.

Definition of Country Indicators and Measures

A review of climate change adaptation drivers and barriers based on existing literature, together with IFC's field observations of private sector needs and motivations on adaptation, informed the definition of a set of indicators measuring whether countries have favorable conditions in place to promote private sector adaptation. Each indicator has been broken down into one or more specific measures (e.g. characteristics of data/information available in-country, existence/absence of given policies) that, once combined, are capable of assisting with assessments of country enabling environments.

Further, six worldwide companies from the agribusiness, manufacturing and utility sectors were consulted to understand what factors among the existing universe of drivers and barriers are the most critical in enabling, incentivizing and constraining private sector adaptation (see Appendix A). These consultations consisted of a questionnaire for senior corporate managers asking them to indicate the priority drivers and barriers influencing adaptation, and phone interviews to understand what motivates their decisions to adapt/not adapt or delay action.

The benefits of adapting are known to outweigh the costs of climate change over the medium- to long-term in several cases. However, there is little information to date on the business case for putting in place mechanisms that enable/incentivize and/or remove barriers to adaptation in the private sector. In an effort to clarify the benefit-to-cost ratios of investments in data/information, institutional arrangements, policies, economic incentives, and communication, technology and knowledge for private sector adaptation, some information on costs and benefits has been provided, where available.

Section 4 presents the indicators and measures of the Index Framework, as well as the underlying business case analyses.

Piloting the Index Framework in Three Countries

Three countries from different regions of the world—a low-income, middle-income and a high-income country[a]—have been selected as pilots for testing the indicators and measures defined in the Index Framework. All three countries have been the stage of some climate change adaptation work in recent years, however they demonstrate different levels of strengths and weaknesses on promoting private sector adaptation. The results of this analysis are summarized in Section 5.

This pilot application is intended to shed light on how the Index Framework could be used to determine in given countries what favorable conditions are present, and which ones are missing, to motivate the private sector in taking action on climate change adaptation. It also contributes to inform governments and funding agencies on where gaps in data/information, institutions, policies, economic incentives, communication, technology and knowledge exist, and on possible capacity needs that must be addressed for private sector adaptation.

[a] Based on the World Bank's country lending groups.

4

Drivers and Barriers to Climate Change Adaptation in the Private Sector

Little is known about the magnitude of climate change adaptation efforts and investments in the private sector, particularly in SMEs. This is partly because actions with climate change resilience benefits are being taken on grounds other than climate change and, as a result, are not reported as adaptation actions, and, in some instances, such as R&D, operational or capital expenditures, information remains confidential.

Climate change adaptation in the private sector can take multiple forms: from commissioning studies on future changes in the performance of select assets or operations to investing in 'climate-proofing' measures (e.g. flood defences) or purchasing insurance to transfer given risks. It is by nature context-specific and a function of economic activities (including the local and/or global footprint of operations and value chains), bio-climatic conditions and socio-economic factors. As a result, most of the existing literature on private sector adaptation has been focused on setting up the stage for discussions or on analyzing sectoral issues, rather than evaluating the magnitude of private sector investments or progress in mainstreaming climate change considerations in private sector planning and decisions-making.[3]

At its core, what motivates the private sector to take climate change adaptation action is simple: maintaining or increasing value (e.g. revenues, credit, reputation) and/or keeping costs down (e.g. loss and damage, business interruption, capital expenditures and operational expenditures), and following relevant regulation and policies. However, at a more granular level, there is a suite of factors influencing private sector adaptation. Identifying how decisions about whether and how to adapt are made, constituted the basis for identifying the factors that influence private sector adaptation, namely the availability and scope of:

- Data and information;
- Institutional arrangements;
- Policies;
- Economic incentives; and
- Communication, technology and knowledge.

Out of the universe of existing drivers and barriers influencing private sector adaptation, there are several factors that play a critical role in creating enabling environments. Some are external to an organization and/or individual (e.g. market and/or policy environments), and others are internal and based on perceptions and experience. For instance, previous negative experiences associated with natural disasters or extreme weather have often been correlated with higher levels of engagement on climate change adaptation.[4]

While little can be done to evaluate and/or influence at a country level internal factors of private sector adaptation, opportunities exist to leverage external factors in order to understand and improve country enabling environments. Some of those opportunities have been identified in the climate change adaptation

literature. For instance, OECD has found that the following factors play an important role for companies:

- Ability to finance adaptation that involves considerable upfront expenditures and medium- to long-term benefits;
- Capacity and expertise to carry out climate risk, opportunity and adaptation assessments;
- Existence of research institutions and partnerships with governments and scientists; and
- Policies, laws and regulations encouraging or requiring climate change adaptation.[5]

However, this does not capture the full extent of factors that can influence private sector adaptation, especially with regards to small- and medium-size enterprises (SMEs) and smallholders (e.g. farmers and fishermen) in developing countries. These actors face another set of challenges around awareness and resources. For example, offering microfinance programs and/or improving access to critical information and communication technologies (e.g. internet) are likely to play a critical role in enabling climate change adaptation for these actors.

In an effort to capture the needs and constraints of all private sector actors, including multinationals, industry associations, SMEs and smallholders, Table 1 presents the set of drivers and barriers that have been identified to play a critical role in enabling/incentivizing and/or discouraging climate change adaptation. Additional factors have been considered as part of this work, however they have been filtered out as playing a smaller role in influencing private sector adaptation thanks to feedback from the private sector and IFC's field observations (see Appendix A). This set of factors provided the basis for defining the indicators and measures of enabling country environments for private sector adaptation presented in Section 4.

TABLE 1: Factors Influencing Climate Change Adaptation in the Private Sector

Data and information
▪ Free and easy access to climate (e.g. temperature, precipitation, sea level rise, solar radiation, wind) and hydrological (e.g. soil moisture, groundwater, runoff, evaporation, flood) *observations* elaborated for specific sectoral and geographic needs.
▪ Free and easy access to climate (e.g. temperature, precipitation, sea level rise, solar radiation, wind) and hydrological (e.g. soil moisture, groundwater, runoff, evaporation, flood) *projections* elaborated for specific sectoral and geographic needs.
▪ Climate/hydrological observation and projection datasets in a temporal and spatial resolution that are relevant to business decision-making (e.g. hourly/daily data, near-term timescales and spatial resolution of 50km^2 or less) and in a business-friendly format (e.g. in the form of indices avoiding the need for data manipulation).
▪ Data/information readily available on select impacts taking into account climate projections (e.g. flood risk maps, surface/ground water hydrographs, fire risk maps, rainfall intensity-duration-frequency curves).
▪ Decision-support tools to understand and assess risks and opportunities, and/or identify and select adaptation actions elaborated for specific sectoral and geographic needs.
▪ Data/information about the climate change risks and adaptation needs of communities, as well as that related to environmental concerns, which enables the private sector to take them into account in its adaptation process.
▪ Data/information about the costs and benefits of climate change adaptation actions.
▪ Data/information on climate-related insurance loss claims and insurance products/premiums for selected climate-related risks.
▪ Data/information about diversification strategies to adapt to climate change (e.g. available options, costs and benefits) elaborated for specific sectoral and geographic needs.
▪ Data/information about trends in operational performance and/or demand for climatically sensitive products or services (e.g. trends in crop productivity vs. trends in climate) elaborated for specific sectoral and geographic needs.
▪ Sector-specific data/information about locations vulnerable to climate change and locations favored by climate change (e.g. sector-specific vulnerability/hazard maps).
▪ Data/information and/or promotion of new products and services where a changing climate creates competitive advantages.
Institutional arrangements
▪ Coordinating agencies made of government, private sector, civil society, NGOs and/or academia with activities focused on climate risk and adaptation, including funding for climate change adaptation in the private sector.
▪ Public-private partnerships dedicated to assessment of climate change adaptation challenges, and provision of solutions.
▪ Brokers and other intermediaries active in environmental trading markets with climate change adaptation benefits (e.g. water markets).[a]
▪ Government and/or industry organizations that, considering climate change risks, provide support to alternative productions/activities and/or relocation in the private sector (e.g. government export agency).
Policies
▪ Building codes and building standards taking into account changing climate conditions and the associated impacts on building design and operations (e.g. insulation for projected changes in temperatures and precipitation, updated intensity-duration-frequency rainfall information for stormwater, drainage, wastewater and flood management infrastructure).
▪ Local zoning regulations incorporating data/information about future changes in climate and their impacts on new and/or existing infrastructure and buildings
▪ Land use/construction permitting rules promoting climate change adaptation measures (e.g. permits used to promote tree planting to cool urban areas or absorb more water where the Urban Heat Island effect or flooding pose risks).
▪ Land tenure policies and laws/regulations that secure over the long-term the land rights of vulnerable populations who may be more at risk from expropriation and/or land loss due to climate change impacts (e.g. more severe floods) or due to actions by other groups (e.g. land purchase or leasing by organizations looking for more climate resilient locations).
▪ Stakeholder consultation and/or engagement requirements promoting disclosure and/or consideration of climate risks, opportunities and adaptation.
▪ Environmental and/or social impact assessment laws/regulations and/or government guidance with requirements to assess the impacts of changing climate conditions and consider adaptation measures (e.g. the European Commission 2013 *Guidance on Integrating Climate Change into Environmental Impact Assessment* and the pending proposal to revise the EIA Directive).
▪ Legal/regulatory obligation on operators of critical infrastructure (e.g. utilities) to incorporate and, where necessary, disclose climate change risks and opportunities in their strategic and operational plans (e.g. supply/demand forecasts, Integrated Resource Management Plans).
▪ Laws/regulations authorizing regulated utilities to offer differentiated tariff/service options making it possible to reflect customer choices on security of supply on cost of water/energy during periods of scarcity.

(continued on next page)

TABLE 1: Factors Influencing Climate Change Adaptation in the Private Sector (*continued*)

Economic incentives
▪ Incentives in support of purchases of climate change adaptation technologies and/or implementation of adaptation actions and/or R&D in the private sector (e.g. water efficiency incentives).
▪ Public and/or private financing instruments (e.g. loans, equity or guarantees) in support of climate change adaptation uptake in the private sector, including purchase of technologies, implementation of adaptation actions and/or R&D (e.g. loans for water efficiency investments).
▪ Microfinance programs for SMEs and smallholders in support of purchases of climate change adaptation technologies and/or implementation of adaptation actions and/or R&D (e.g. microloans for investing in drought-resistant crops).
▪ Charges and/or levies used to fund climate change adaptation works in the critical public infrastructure.
▪ Carbon finance supporting activities that improve climate change resilience while reducing greenhouse gas emissions.
▪ Environmental trading markets promoting efficient use of environmental resources under pressure from climate change impacts and generating additional revenue opportunities (e.g. water markets).
▪ Insurance or financial risk management products that transfer climate-related risks, while incentivizing risk reduction actions.
Communication, technology and knowledge
▪ Professional post-secondary education curriculums incorporating climate change impacts and adaptation knowledge and/or training (e.g. engineering, environmental/social management, geology, biology, business and public administration and economics).
▪ Climate change adaptation technologies and/or process innovation are produced, sold and/or promoted in the private sector (e.g. water-efficient irrigation, hard flood defence structures, drought-resistant crops, desalination, sensor technology).
▪ Information and communication technology infrastructure enabling user applications and software for climate change adaptation (e.g. early disaster warming and climate information can be provided to farmers via mobile phones).
▪ Mechanisms encouraging technology/knowledge transfer and/or sharing of best practices between countries and/or regions, as well as across sectors.
▪ Tools to analyze and compare the effectiveness and efficiency of different diversification options (e.g. different crops or different areas of operations).

[a] Environmental trading markets enable actors to trade environmental entitlements (a set of share of a pool of environmental resources) and/or allocations (an amount of environmental resource given over a timer period) within a market framework.

5 Indicators of Country Conditions Enabling Private Sector Adaptation to Climate Change

Sixteen indicators has been defined as the initial set of the Index Framework. This set of indicators is by no means definitive—other indicators, including those from Table 1 need to be incorporated for a comprehensive set—but it provides an indication of some of the key conditions that a country needs to have in place to create an enabling environment promoting adaptation in the private sector and socio-economic prosperity in a changing climate.

Having enabling country environments in place for private sector adaptation can be a motor for economic growth and opportunities. For instance, the United Kingdom government estimated the contribution of climate change adaptation goods and services to the world's economy at US$104.3 billion in 2010/11, US$5.2 billion of which was generated in the United Kingdom. Extrapolating these numbers into the future using projected growth rates, by 2020 adaptation goods and services could be worth US$186.1 billion worldwide, the equivalent of 0.2% of the projected 2020 global Gross Domestic Product.[b] Given that climate change adaptation is very much in its infancy, and developed countries have committed to increase funding for mitigation and adaptation for developing countries from today's level of US$10 billion annually[c] to US$100 billion each year from 2020 onward, the value of private sector revenues from climate change adaptation will most likely exceed US$186 billion yearly by 2020.

Beyond promotion of climate change adaptation, there are a host of economic reasons for having in place incentives and removing barriers to adaptation: from avoiding costly loss and damage due to increased flooding, to increasing revenues and jobs in economic activities favored by a warmer climate. In the past eight (8) years, economists around the world have demonstrated that there is a strong business case for governments to take action on climate change risks, opportunities and adaptation. The World Bank has estimated that by spending only 0.2% of their projected revenues on adaptation (between US$70 and 100 billion between 2010 and 2050), developing countries can avoid a large share of future loss and damage due to climate change impacts.[6]

The benefits of adapting to climate change do not stop at avoiding damage and loss; the private sector also stands to reap rewards over time from adaptation investments. Using available cost data and information as well as corporate examples, this section

[b] Based on projected global GDP of US$95,000 billion in 2020 and forecast year-on-year growth rates for climate change adaptation goods and services estimated by the UK government out to 2017–2018 (using an annual growth rate of 7.1% between 2018 and 2020). See www.gov.uk/government/uploads/system/uploads/attachment_data/file/31721/12-p144-adaptation-and-resilience-climate-change-2010-11.pdfand www.usinnovation.org/sites/default/files/Global-Economic-Outlook%20_The-Conference-Board.pdf.

[c] Based on US$30 billion developed countries committed to deliver as Fast Start Finance for climate change for 2010–2012.

TABLE 2: Indicators for the Index Framework To Evaluate Whether Countries have in Place Favorable Conditions To Promote Climate Change Adaptation in the Private Sector

Indicator	Description
Data and information	
1. Climate and hydrological projections	National climate (e.g. temperature, precipitation, humidity, solar radiation/cloud cover and wind) and/or hydrological (e.g. soil moisture, groundwater, runoff, evaporation, flood/drought) projections based on calibration and validation of climate and hydrological models
2. Direct and indirect impacts	National data/information about climate change direct and indirect impacts relevant to the private sector and elaborated for specific sectoral and geographic needs
3. Adaptation measures, costs and benefits	National data/information about climate change adaptation measures, and associated costs and benefits, elaborated for specific sectoral and geographic needs
4. Community vulnerability, risk and adaptation	National/local data/information about community vulnerability and risk from climate change and/or adaptation priorities
Institutional arrangements	
5. Institutions and forums	Coordinating national bodies and forums with a role in facilitating climate change adaptation in the private sector
Policies	
6. Building standards and/or codes	Building standards and/or codes incorporating climate change impact and adaptation considerations
7. Public infrastructure	Public and key infrastructure having factored climate change impacts and adaptation into design, operations and/or decommissioning
8. Local zoning rules	Local zoning rules incorporating climate change impact and adaptation considerations for new and/or existing infrastructure/buildings in areas vulnerable to climate change (e.g. floodplains, coastal zones, glaciers)
9. Permitting and impact assessments	National/local permitting (e.g. land use and/or construction permits) and/or environmental/social impact assessment rules incorporating climate change impact and adaptation considerations into developments
10. Investor relations and/or stakeholder management	Incorporation of climate change impact and adaptation considerations in instruments and practices for investor relations and stakeholder management (e.g. disclosure in security fillings, bond prospectuses, stakeholder consultation, community resettlement and compensation)
Economic incentives	
11. Government incentives	Government incentives promoting climate change adaptation in the private sector
12. Finance	Public and/or private finance instruments (e.g. loans, equity, guarantees) for climate change adaptation, including planning, implementation, purchase of equipment and material, and innovation/R&D in the private sector
13. Full-cost accounting for water and energy	Cost accounting and pricing practices in water and energy utilities, which reflect the 'true' lifecyle costs of the impacts of more extreme weather and climate change on water and energy management and services, and which incentivizes increased efficiency, reduced consumption and improved resilience
14. Environmental trading markets	Markets to trade environmental entitlements or allocations (e.g. over water, soil and/or biodiversity resources) under pressure from climate change
Communication, technology and knowledge	
15. Information and communication technologies	Availability and market penetration of information and communication technologies (e.g. internet and mobile cellular)
16. Technology and knowledge	Access to and use of technology and knowledge useful to understand, assess and respond to climate change risks and opportunities

explains the costs and benefits associated with the sixteen indicators defined in this report. The indicators are summarized in Table 2, and further descriptions, including associated costs and benefits, are provided in the following paragraphs.

INDICATOR 1: Climate and Hydrological Projections				
Description	**Measures**	**Costs**	**Benefits**	**Business case summary**
National climate (e.g. temperature, precipitation, humidity, solar radiation/cloud cover and wind) and/or hydrological (e.g. soil moisture, groundwater, runoff, evaporation, flood/drought) projections based on calibration and validation of climate and hydrological models	▪ Free access to data/information from a national or international body (e.g. government department, public agency, research center, donor organization) ▪ Data available electronically ▪ Data available in both raw format as well as maps or graphs (e.g. cumulative frequency distributions) ▪ Downscaled projections ▪ Data available on primary (e.g. average, maximum and minimum temperature and precipitation) and derived (e.g. growing season length, hot/cold days, flood/drought indicators, soil moisture) hydro-climate variables	▪ Installation, operation and maintenance of hydro-meteorological observation network ▪ Climate modeling capability ▪ Research costs ▪ Data/ information diffusion	▪ Avoided loss and damage from climate-related hazards ▪ Avoided business interruption ▪ Better mid- to long-term planning and/or pricing decisions enhancing profitability ▪ Increased revenue opportunities (e.g. new insurance products)	The costs of producing climate and hydrological projections are likely outweighed by potential avoided costs and increased revenue opportunities – the World Bank estimates that hydrometeorological investments in Russia and Central Asia have benefit-to-cost ratios between 5 to 1 and 53 to 1

Virtually all private sector activities depend on climate and hydrological data/information, from sectors reliant on natural resources or crops to sectors vulnerable to natural hazards in their operations and/or value chains. As such, factoring data and information on future changes in hydrometeorological (hydromet) variables into planning and decision-making is an essential step to build climate change resilience in the private sector.

Projections are not all of the same quality or format, and this bears implications for adaptation. Countries with national long-term climate (e.g. temperature, precipitation, humidity, solar radiation/cloud cover and wind) and hydrological (e.g. e.g. soil moisture, groundwater, runoff, evaporation, flood/drought) projections based on models calibrated and validated with observed hydromet data are steps ahead in the promotion of adaptation. The conditions for adaptation are the most favorable in countries where such projections are i) freely accessible through national or international bodies such as government departments, special agencies, research centres and/or donor organisations; ii) available electronically; iii) distributed in raw format as well as in the form of maps or graphs (e.g. cumulative frequency distributions); iv) of high spatial resolution thanks to dynamical or statistical downscaling techniques; and v) include not only primary variables but also compound and derived variables relevant to private sector planning and decision-making (e.g. growing season length, hot/cold days, flood/drought indicators, soil moisture).[d]

Development of climate and hydrological projections requires, among other things, access to quality hydromet observations for calibration and validation of models, as well as in-country capabilities in climate and hydrological modeling.[e] Beyond improving the quality of climate model projections, quality hydromet observations also offer a large range of economic benefits. For instance, they improve disaster warnings that can prevent all or part of loss and damage from natural hazards. Using disaster warnings, farmers can protect their crops, businesses can storm-proof their buildings, and dam operators can start reducing reservoir levels to decrease peak flood levels.[7] Quality hydromet observations also enable the production and distribution

[d] For a definition of primary, compound and derived variables, refer to Willows, R.I. and Connell, R.K. (eds) 2003. *Climate Adaptation: Risk, Uncertainty and Decision-Making*. UKCIP Technical Report. UKCIP: Oxford, UK.

[e] In recent years, the use of remote-sensing data from satellites to analyze climate in areas where monitoring is sparse has increased; however, remote sensing can never fully substitute for surface-based measurements.

of non-disaster data and information helpful for planning. For instance, farmers can make better decisions about crop planting and fertilization based on rainfall predictions. Investments in hydromet monitoring also bear non negligible indirect benefits: for example, it is based on hydromet data and information that insurers make pricing decisions and develop new weather insurance products, and that power generators maximize the output of hydropower plants and decide on new asset investments.

The costs of installing, operating and/or maintaining a good network of hydromet monitoring stations vary depending on country size and transportation access. Based on twelve selected World Bank projects, the average cost of comprehensive hydromet improvements for developing countries amounts to over US$30 million.[8] Such costs may seem significant for cash-strapped developing countries, however they generate large benefits. In fact, many developing countries, especially in Africa, are known to suffer from poor hydromet networks with sparse and deteriorating monitoring stations translating into spotty and often inaccurate data. In Central Asian countries, the number of meteorological and hydrological stations in operation has dropped by 22 to 62% and 41 to 48% between 1985 and 2008 respectively, despite the fact that the impacts of current and future climate constitute large threats to the socio-economic stability and prosperity of the region.[9]

Several studies confirm the net positive economic value of long-term climate and hydrological projections, though differences in benefits exist between economic sectors and countries. For example:

- The yearly value of El Niño Southern Oscillation (ENSO) forecasts for Mexico's agricultural sector has been estimated to range between US$8.3 and 19 million for different ENSO frequency probabilities (at a 70% forecast skill level), thanks to improvements in agricultural output and changes in the number of hectares planted, whereas the value of such forecasts has been calculated at between US$240 and 323 million each year for the US agricultural sector (for forecast skill levels ranging from modest to perfect);[10]
- Improved streamflow forecasting in the United States Columbia river basin has the potential to increase spot market sales of hydroelectricity by US$161 million a year.[11]

However, little work has been done to strictly quantify the return on investment of projects aimed at developing long-term climate projections. For instance, the cost born by the United Kingdom government for producing its latest probabilistic climate projections, known as UKCP09, amounted to over US$17 million, 12 million of which supported the costs of the Met Office supercomputing. While costly, this investment resulted in 'state-of-the-art' climate change data/information which has since seen significant uptake in the United Kingdom impacts and adaptation community.[12] Beyond that, there is no official estimate on the benefits of UKCP09 to the United Kingdom economy. Similarly, the European Commission invested close to US$20 million between 2004 and 2009 to support over US$33 million worth of research on developing an ensemble of climate projections for Europe.[13] While the exact return on investment remains uncertain, the data/information generated have since been used in a number of studies on future impacts and adaptation.

In comparison, there is much more knowledge about the return on investment of projects aimed at improving hydromet observations. As an example, the World Bank has found that hydromet investments in South Eastern Europe have benefit-to-cost ratios over five years between 1 and 11 to 1.[14] Similar benefit-to-cost ratio calculations for Russia (between 5 to 1 and 10 to

1) and Central Asia (between 23 to 1 and 53 to 1) confirm that the business case for such investments is strong.[15]

Recently, the Pilot Program for Climate Resilience of the Climate Investment Fund has identified US$95 million in hydromet investments to reduce climate change vulnerability and facilitate adaptation. One of these investments estimated the costs of modernizing Nepal's hydromet observation network, improving its forecasting systems, and strengthening its capacity to provide weather, climate and hydrological data and information at US$31million.[16] The expected benefits for Nepal's economy include the increased financial sustainability of Nepal's Department of Hydrology and Meteorology, improved accuracy and timeliness of projections, and increased value to data users.

INDICATOR 2: Direct and Indirect Impacts				
Description	**Measures**	**Costs**	**Benefits**	**Business case**
National data/information about climate change direct and indirect impacts relevant to the private sector and elaborated for specific sectoral and geographic needs	▪ Data/information about direct and indirect climate change impacts including flood risk maps, surface/ground water hydrographs, fire hazard indices, rainfall intensity-duration-frequency curves ▪ Data/information tailored to the needs of different economic sectors/locations/sizes (e.g. growing season length for the agricultural sector, Heating/Cooling Degree Days for the building sector)	▪ Capability to model direct and indirect impacts (e.g. flood, drought, crop yields) ▪ Research costs ▪ Data/information diffusion	▪ Avoided loss and damage from climate-related hazards ▪ Avoided business interruption ▪ Better mid to long-term planning and/or pricing decisions enhancing profitability ▪ Increased revenue opportunities (e.g. flood-resistant materials)	Despite the potentially high costs, investing in research on climate change impacts potentially trigger benefits that outweigh costs in the form of avoided loss and damage and increased revenue opportunities

There is a dearth of data and information on *where*, *when* and *by how much* climate change will affect the private sector. In a 2011 survey of 60 worldwide financial institutions, less than 30% of respondents felt sufficiently informed on expected changes in climate for specific locations and on the quality and confidence of such information, and over 60% acknowledged the lack of information on climate change impacts for specific sectors.[17] Although knowledge of how past and current climate affects the private sector has somewhat improved, much remains to be done to improve data/information on future impacts.

Virtually, all private sector organizations will face risks and/or opportunities associated with a changing climate. In 2010, over 90 percent of companies worldwide reported that they had suffered from climate-related impacts in the previous three years.[18] Climate change can affect the private sector in a number of different ways: by creating new business opportunities, affecting the supply of raw materials, interrupting transport and logistics, damaging infrastructure and physical assets, reducing revenues, and creating other indirect impacts. Among the host of climate change impacts, flooding and water scarcity are top concerns in the private sector. In recent years, water-related loss and damage has risen greatly to become a significant share of global insured losses. Further, it is known that a warmer climate and rising sea levels will aggravate flood risk in many parts of the world.[19] By the 2070s, total asset value exposed to coastal flooding in 136 of the world's largest port cities could increase tenfold compared to 2005 levels and reach US$35,000 billion due to the combined effect of sea level rise, land movement, population growth and coastal urbanization.[20] The effects of increased flood risk are already starting to be felt today: the 2011 floods in Thailand harmed more than 14,500 companies worldwide reliant on Thai suppliers and cumulated to overall losses worth US$40 billion approximately.[21]

Water scarcity has also risen to one of the world's top risks, and it is now high on the agenda of the private sector. Reports of businesses suffering from reduced water supply have multiplied in recent years. Two among many examples include:

- Électricité de France which suffered a loss of US$431 million during the 2003 summer heatwave when it limited and suspended operation of several of its power plants due to restrictions on discharge water temperature and the high costs of electricity on the open market;[23] and
- Agribusiness and food company Bunge which reported a loss of US$56 million in the third quarter of 2010 in its sugar and bioenergy business unit due to drought conditions in its main growing areas in Brazil.[24]

Yet, in many countries very little reliable information is available about future flood and/or drought risk in a changing climate. For instance, following the 2011 floods in Thailand, insurers and re-insurers started complaining about the country's rudimentary flood modeling which creates considerable uncertainty in understanding flood frequency and estimating future potential insured loss. In fact, since 2011 a number of initiatives have launched in Thailand to remediate the lack of reliable data/information on flood risk, including: a risk modeling service by Impact Forecasting, a risk mapper for insurers by Munich Re and a database of industrial parks with associated maps by Guy Carpenter.[25]

Flood risk maps are among the tools that are known to provide essential data/information to governments and the private sector in support of climate change adaptation decisions such as land use planning, emergency planning, policy development, investments in flood risk management, purchase of insurance policies, and/or relocation to areas less prone to flooding. Flood risk maps generally provide information on flood hazards from defined sources (e.g. river, ocean/sea, stormwater) by delimiting areas prone to flooding. The quality and amount of information contained in flood risk maps can vary greatly to include one or several of the following:

- Terrain and existing and/or planned developments;
- Flooding depth, velocity, direction and return period; and
- Existing and/or planned flood defences.[26]

Overall, very few governments around the world have updated their flood risk maps to incorporate climate model projections. For instance, even in countries such as the United Kingdom where flood risk mapping is considered of high quality and high resolution climate model projections are available, flood maps do not take fully into account the effect of climate change on rainfall and sea level rise, though plans exist to update flood maps.[27]

The effort and resources necessary to produce reliable flood risk maps incorporating climate change impacts depend on the amount and quality of available data in-country (e.g. laser scan terrain data, satellite images, runoff discharge data, bathymetric data), and the flood risk model used (e.g. one, two or three dimensional models differ in software costs and computer model runtime).[28] Without taking climate change into account, the costs of flood risk mapping alone can be significant: the United States Association of State Floodplain Managers estimates that the Federal Emergency Management Agency (FEMA) would need between US$4.5 and 7.5 billion to produce accurate flood risk maps and US$116 to 275 million annually to keep these maps up-to-date.[29]

Recognizing that a changing climate will have impacts on flood risk, Canada's province of Newfoundland and Labrador updated its flood risk mapping template to take into account climate model projections and it supported the development of a model to convert data on future rainfall into flood risk information.[30] To improve knowledge about flood and climate change vulnerability, the Newfoundland and Labrador government has committed close to US$1 million over 2011–2014 to assess the need for new or updated flood risk mapping studies that incorporate climate model projections, and to undertake flood risk mapping studies that incorporate climate change impacts.[31]

Overall, the potential avoided loss and damage thanks to better flood risk management are expected to largely trump the costs of flood risk mapping. For instance, using flood data from FEMA's *Hurricane Sandy Impact Analysis* and the United States Geological Survey's reports on high water marks, researchers have managed to predict the extent

of flooding caused by Hurricane Sandy in New York and New Jersey.[32] Had this information been factored into local development planning and zoning before Hurricane Sandy hit, a portion of the US$65 billion economic loss could potentially have been avoided.[33] The updated flood maps released in 2013 by FEMA for the New York City region have been heavily criticized for leaving out sea level rise projections with fear that they would trigger non-resilient insurance requirements, building codes and local zoning regulations.[f, 34]

Although cost estimates for the production of data/information about other types of climate change impacts relevant to the private sector (e.g. drought risk) are not as widely available, benefits are likely to outweigh the costs, similarly to the return on investment of flood risk mapping.

[f] Under the Biggert-Waters Flood Insurance Reform Act adopted by Congress in 2012, FEMA is required to consider „the best available science regarding future changes in sea levels, precipitation, and intensity of hurricanesĐ in its flood risk maps; however the updated flood risk mapping for New York City had been started before this law came into force.

INDICATOR 3: Adaptation Measures, Costs and Benefits				
Description	**Measures**	**Costs**	**Benefits**	**Business case**
National data/information about climate change adaptation measures, and associated costs and benefits, elaborated for specific sectoral and geographic needs	▪ Data/information about climate change adaptation measures and associated costs and benefits, including measures such as flood protection, irrigation and water/energy efficiency ▪ Case studies of climate change adaptation in the private sector	▪ Research costs ▪ Data/ information diffusion	▪ Better mid- to long-term planning and/or pricing decisions enhancing profitability (e.g. increased production potential) ▪ Improved capability to make cost effective and efficient adaptation decisions ▪ New financial products/services (e.g. financial risk transfer instruments)	Improving data/information on adaptation costs and benefits has been shown to leverage private sector investments in adaptation—IFC's work with a Latin American port operator has leveraged private sector adaptation investment by a factor of 80

Costing climate change adaptation is crucial to the private sector, and not without good reason: sound planning requires forward-looking financial information on potential costs, revenues and operating environments. Without such information, it is very difficult to justify taking action on the basis of climate change impacts that may occur in the future and are uncertain, as well as to understand the economic returns of adaptation. An initiative recently launched in the United States on the economic risks of climate change ('RiskyBusiness') illustrates the profile that climate change costing has taken on for the private sector. Business tycoon, Michael Bloomberg, and former United States Secretary of the Treasury, Hank Paulson, have joined forces to fund a US$1.2 million study aimed at quantifying the potential future costs of climate change so that leaders across sectors of the United States economy can start preparing a measured response to those risks.[35]

A number of other initiatives worldwide have produced data/information on the economics of climate change adaptation through the use of different methods. Cost-benefit analysis (CBA) has been used to appraise the costs of adaptation actions (e.g. the cost of flood-proofing a building or of switching to drought-resistant crops) and their associated benefits and/or avoided loss/damage (e.g. avoided flooding damage or business interruption or improved crop production due to enhanced climate suitability) in order to compare different adaptation options. Importantly, CBA has helped to put in perspective the costs of *inaction*, which more often than not exceed adaptation costs.[36] Probably the most high profile example of such work has been the 2007 *Stern Review* in the United Kingdom which famously found that under 'business-as-usual' scenarios inaction on climate change impacts could cost between 5% and 20% of global consumption per capita every year now and forever.[37] More recently, the World Bank's *Economics of Adaptation to Climate Change* estimated the costs of adapting to a changing climate for all developing countries.[38] These adaptation cost estimates range from US$70 to 100 billion between 2010 and 2050, a sum equivalent to the amount of foreign aid that developing countries receive each year. Economic analysis methods other than CBA (e.g. robust decision-making) have also been used to produce data/information on the business case of adapting to a changing climate.[39]

However, most of this work has considered costs and benefits to national and/or local governments rather than private sector implications. Further, very few private sector organizations have publicized quantified climate change impact and adaptation data/information, beyond the costs of single weather-related disruptions. As a result, little is known about adaptation costs and benefits in the private sector. The work of the *Climate Risk Program* of the IFC Climate Business Group is worthy of mention here as an initiative that aims to fill in part of this data/information

gap. In an effort to help its clients understand and respond to the risks and opportunities of a changing climate, IFC has carried out five studies that analyze the costs of impacts and adaptation options for private sector clients in different world regions and economic sectors, more specifically:

- A run-of-the-river hydropower plant (Khimti Khola 1), owned and operated by Himal Power Ltd in Nepal;
- An hydropower project in Zambia's Kafue basin (KGL HP);
- An edible palm oil producer in Ghana (Ghana Oil Palm Development Company);
- A paper manufacturing operation by Packages Limited in Kasur, Pakistan (Bulleh Shah Paper Mills); and
- A cargo seaport operator in Cartagena, Colombia (Terminal Marítimo Muelles El Bosque).[40]

To date, this work has shown that adaptation costs and benefits are highly specific to the assets or processes being adapted, and that uncertainty about future extreme climate makes it difficult to quantify the economics of climate change adaptation reliably in some cases.[41]

The potential benefits of improving private sector data/information on the business case of climate change adaptation are demonstrated by the efforts of two companies. First, *Terminal Marítimo Muelles El Bosque* (MEB), a major cargo seaport operator in Cartagena, Colombia, collaborated with the IFC to understand the implications of climate change for the key components of its operations, including trade levels and patterns, navigation and berthing, cargo handling and storage, and transportation within and beyond the port fencelines. The study estimated that increased flood risk due to sea level rise could cause an annual loss in projected revenues of 3% to 7% by 2032. MEB decided to act upon the study recommendations and invest US$20 million to reinforce its resilience through infrastructure improvements. In this example, IFC's original investment in the study of approximately US$200,000 achieved a private investment leverage factor of 80. Second, the American utility company Entergy Corporation participated in the *Building A Resilient Energy Gulf Coast* study with America's Energy Coast, America's Wetland Foundation and Swiss Re in order to develop fact-based approaches to quantify climate change risks and opportunities, and inform economically-sensible adaptation approaches in the United States Gulf Coast.[42] The study estimated that the Gulf of Mexico could suffer over US$350 billion in cumulative losses by 2030 due to possible increases in wind speed and storm surges, and sea level rise. It also identified a number of 'no regrets' adaptation actions that have clear positive returns on investment and reduce a considerable portion of the risk (e.g. beach nourishment, improved standards for offshore platforms or levees to protect refineries and petrochemical plants against flooding). With these findings, Entergy is better equipped to allocate resources and implement priority adaptation actions.[43] These two examples show that resources spent on improving data/information about the economics of climate change adaptation in the private sector are capable of leveraging investments in the private sector.

Research on climate change adaptation costs and benefits can generate considerable value. For instance, the United Kingdom government funded the US$1.3 million *Economics of Climate Resilience* project to assess the economic case for adaptation and identify where action is the most beneficial.[44] The results of this work has informed the United Kingdom *National Adaptation Program* which lays out objectives, policies and proposals to address the higher order risks among the 700 risks identified in the country's *2012 Climate Change Risk Assessment* and avoid considerable future loss and damage.

INDICATOR 4: Community Vulnerability, Risk and Adaptation				
Description	**Measures**	**Costs**	**Benefits**	**Business case**
National/local data/information about community vulnerability and risk from climate change and/or adaptation priorities	▪ National/local climate change vulnerability/risk and adaptation assessments (e.g. reports and/or resource centres)	▪ Research costs ▪ Stakeholder engagement ▪ Data/ information diffusion	▪ Access to community-held data/information ▪ Maintain community performance and social license ▪ Exploitation of 'shared opportunities' between communities and private sector ▪ Avoided costly interruptions of economic activity	The costs of producing data/information on community vulnerability, risk and adaptation are likely outweighed by positive social and environmental benefits (e.g. new sources of livelihoods)

In any part of the world, the success of the private sector relies on the prosperity of local communities. Communities form essential parts of economic value chains by providing key resources to the private sector such as a workforce, essential supplies, a customer base and a social license to operate.

There are several reasons for the private sector to assess climate change risks, opportunities and adaptation options, and implement risk management measures while taking account of communities. For instance:

- Understanding the vulnerability and risks faced by a community due to the changing climate and/or its adaptation priorities/actions can provide useful insights to the private sector on its own vulnerability, risks, opportunities and adaptation;
- The impacts of climate change could affect social licenses to operate if nothing is done to maintain social and/or environmental performance under different climatic conditions;
- By factoring into private sector decisions and practices the fact that climate change can create and/or exacerbate community concerns over the sharing of resources, potential conflicts can be avoided and/or mitigated;
- Poorly planned climate change adaptation in the private sector could have negative consequences on local communities; and
- Climate change adaptation creates a new source of 'shared value'[g] opportunities between communities and the private sector.[45]

Several national and local sources of data/information exist on community vulnerability, risk and adaptation issues associated with a changing climate. For instance, most countries have assessed areas of vulnerability and risk and identified possible adaptation interventions to adapt, though the quality of these assessments varies considerably. Under the United Nations Framework Convention on Climate Change (UNFCCC), a large number of the world's least developed countries and all other country parties have prepared and published National Adaptation Programs of Action (NAPAs) and National Communications respectively. These contain data/information about community vulnerability, risk and adaptation. For instance, Cambodia's NAPA identifies key adaptation needs based on household surveys, as well as input from informal leaders, local authorities and non-governmental organizations.[46] The Cancun Adaptation Framework adopted at the UNFCCC sixteenth Conference of the Parties in 2010 created a process whereby all country parties commit to plan, prioritize and

[g] Shared value practices seek to promote activities that create positive financial and social returns for the private sector and communities respectively. See Porter, M., E., and Kramer, M., R., 2011. Creating shared value: How to reinvent capitalism and unleash a wave of innovation and growth. *Harvard Business Review*, February 2011.

implement adaptation actions, and, as part of it, develop National Adaptation Plans (NAPs). While most NAPs are in progress, a number of countries are at a more advanced stage. For instance, the United Kingdom has recently completed its first national *Climate Change Risk Assessment* and *National Adaptation Plan* where it identifies adaptation responses to identified climate change risks in six areas: built environment, infrastructure, health and communities, agriculture and forestry, natural environment, and business and local government.[47] Outside of the UNFCCC process, a number of developed and developing countries have realized national, sub-national and/or sectoral climate change vulnerability, risk and adaptation assessments, thanks to donor funding in some cases. For example, this is the case of Kenya which developed a National Climate Change Action Plan (NCCAP) thanks to funding from the United Kingdom Department for International Development, which was led by its Ministry of Environment and Mineral Resources and validated by over 275 representatives from all of Kenya's 47 counties.[48] While not solely focused on climate change adaptation, Kenya's NCCAP prioritizes adaptation actions and provides associated cost estimates; examples of Kenya's adaptation priorities include US$172 million to upscale resilient practices in the agricultural sector (e.g. drought-tolerant crops, water harvesting, index-based weather insurance, agro-forestry), US$59 million to mainstream climate change into all water resource management plans and action, and US$534 million to strengthen climate change information management systems. Interestingly, the private sector was involved in Kenya's NCCAP process, which demonstrates the relevance of climate change adaptation to private sector interests.[h]

Several companies worldwide have shown how data/information on community vulnerability, risk and adaptation can help to build value chain resilience to climate change impacts in the private sector. For instance, United Kingdom manufacturer of cosmetics products The Body Shop sources raw materials, such as sesame oil and tea tree, from suppliers who have contracts with Community Fair Trade producers. Some of the company's primary producers of sesame in Nicaragua are increasingly facing climate-related pressures, including excess rainfall and droughts. For instance, in 2011 twelve days of heavy downpours cut off transportation access and caused considerable crop losses, forcing a number of sesame producers to emigrate to sustain their families. While The Body Shop has not been hit directly by these events, it sees climate change risk as one of the issues that can put at risk its long-term relationships with suppliers. This is why The Body Shop is working with its suppliers to ensure the resilience of its supply chain and of the community livelihoods that depend on it. As part of it, The Body Shop supports a number of micro-insurance schemes so that its primary producers are protected against weather-induced crop failure.

With the knowledge that climate change could create cumulative costs in excess of US$350 billion in the Gulf of Mexico over the next 20 years, United States utility company Entergy collaborated with America's Wetland Foundation and America's Energy Coast to create the *Blue Ribbon Resilient Communities*. This initiative has helped communities in the Gulf of Mexico where Entergy operates prepare themselves for more extreme weather events through local forums where local

[h] Private sector organizations involved in the development process of Kenya's NCCAP included Kenya Private Sector Alliance, Kenya Airways, Kenya Pipeline Company, Matatu Owners Association, Commercial Bank of Africa Limited, Kenya Bankers Association. See http://cdkn.org/wp-content/uploads/2013/03/Kenya-National-Climate-Change-Action-Plan.pdf.

government and residents assess, analyze and discuss solutions. Through these forums, communities are better informed and armed on climate change resilience planning. In parallel, Entergy has also engaged in discussions with some of its Texas and Louisiana customers, including city manager, county and parish leaders and industrial operators, about climate change vulnerability and risk and strategies to build resilience.

Compared to its benefits, the cost of assessing community vulnerability, risk and adaptation is likely to remain moderate. For instance, Entergy contributed to the *Blue Ribbon Resilient Communities* initiative with a US$400,000 grant. Through this work, the practical lessons that Entergy has learnt on how to build resilience to more extreme weather are likely to protect future corporate and community value in excess of US$400,000. To date, this work has already led to tangible climate change adaptation action. For instance, a number of cities have acquired backup generators for water and sewage systems to deal with climate-related power disruptions, and some communities have begun restoring and protecting marshlands along the coast to provide added protection against increased storm surge flooding.[49]

INDICATOR 5: Institutions and Forums				
Description	**Measures**	**Costs**	**Benefits**	**Business case**
Coordinating national bodies and forums with a role in facilitating climate change adaptation in the private sector	▪ National government and/or private body, consortium or network with a role in facilitating private sector adaptation, including: ▪ Dialogue between the private sector, government, civil society and academia about issues and needs; ▪ Production and dissemination of data/information relevant to the private sector (e.g. case studies, costs and benefits, best practices); and ▪ Capacity-building and support services to understand issues and implement actions. ▪ Multisectoral private sector audience ▪ Participation of and/or benefits to SMEs	▪ Operating costs ▪ Private sector opportunity cost (e.g. staff time and CAPEX)	▪ Improved access to data/information for climate change adaptation ▪ Better mid- to long-term planning and/or pricing decisions enhancing profitability ▪ Improved alignment between private sector, government, civil society and academia creates economies of scale and increases overall climate change resilience	Existing climate change adaptation institutions and forums have shown positive returns on investment—In one Canadian example each dollar of government funding spent has resulted in 40 cents of private sector adaptation investment

Climate change impacts and adaptation are relatively new concerns for the private sector. As such, there is a perception that standards and practices in place dealing with natural climate variability are good enough to cope with more extreme weather and incremental changes in climate, or that considerable costs are required to 'get started' on these issues and build resilience. Working alongside specialized institutions and/or within forums represents a way to understand the relevance and materiality of climate change effectively and cost-efficiently, and approach climate change adaptation in a 'step-wise' fashion. Though the number of institutions and forums explicitly working on climate change adaptation with the private sector remains limited, institutions/forums working in other areas (e.g. disaster risk management, water) sometimes address climate change impact and adaptation issues.

Where they exist, institutions (e.g. specialized bodies or consortiums) and forums (e.g. networks or dialogue platforms) play a catalyst role in promoting private sector adaptation in several countries by:

- Providing a space for dialogue between the private sector, government, civil society and academia;
- Producing and/or disseminating data/information useful to climate change adaptation; and
- Building capacity and/or offering support services to improve the private sector understanding of climate change impact and adaptation issues, and their capability to take action.

The United Kingdom Climate Impacts Programme (UKCIP), one of several good examples, was established by the UK government in 1997 to support climate change adaptation by the public and private sector.[50] Advised by a Steering Committee made of representatives from government departments, public agencies, private companies and NGOs, UKCIP supported a number of climate change impacts and adaptation assessments in the private sector, and developed tools for the private sector.[i] UKCIP also

[i] The Business Areas Climate Assessment Tool (BACLIAT) is one example of UCKIP tools for the private sector. It is a checklist that UK businesses have used to assess the potential impacts of climate change at an organizational level. Private sector applications of BACLIAT include several UK trade associations and professional bodies as well as individual companies including Serco's Colnbrook Immigration Centre at Heathrow, Scottish Electrical Contracting, and several

rolled out a number of activities to assist SMEs, including local and regional workshops, training sessions, and technical studies. In 2011, the Environment Agency took over UKCIP's responsibilities to deliver government's climate change adaptation program and work with the private sector.[51]

The Commonwealth Scientific and Industrial Research Organisation (CSIRO) is Australia's national science agency, and its Climate Adaptation Flagship program is, in part, dedicated to the development of adaptation options for the country's natural resources sectors (e.g. mining industry, fisheries, agriculture, forestry).[52] Australia's National Climate Change Adaptation Research Facility manages a US$-41million multidisciplinary research portfolio of over 100 projects, some of which aimed to directly benefit the private sector.[53]

In Rwanda, government is fostering private sector adaptation through partnerships. The Private Sector Federation, a Rwanda professional body, is working with government on training small- and medium-sized enterprises across the country on the business opportunities associated with Rwanda's climate change policies, including funding available through the country's Environment and Climate Change Fund (FONERWA).[54] FONERWA has made 20% of its US$36 million funding available to the private sector and civil society organisations. In Bangladesh, the government's Climate Change Cell is working on strengthening the capacity of professionals, practitioners and policy makers on preparedness for future climate change impacts thanks to a US$2 million grant from the United Kingdom Department for International Development.[55]

Institutions and forums also constitute platforms for potential partnerships between private sector, government and communities to work on common issues. Working in partnership on climate change adaptation is known to deliver benefits such as reduced demands on resources, knowledge and expertise sharing, improved access to private data/information, and increased resilience outside of organizational boundaries and across private sector value chains. As an example, in 2001 Québec's Consortium on Regional Climatology and Adaptation to Climate Change (Ouranos) was jointly set up by the Québec government, Environment Canada and provincial utility company Hydro-Québec.[j] In 2004, a funding agreement was signed for an initial period of five years giving Ouranos the mandate of working on climate change science, impacts and adaptation. The consortium soon attracted interest from other hydropower generators because of its leading edge research on climate and hydrological modeling,[k] and climate change impacts. Today, Ouranos has become a platform through which several companies get access to data/information on climate change impacts and collaborate on adaptation issues, namely: Rio Tinto Alcan, Ontario Power Generation (OPG) and Manitoba-Hydro, which became Ouranos' affiliated members.

Moreover, institutions and forums on climate change adaptation can help to ensure that actions taken by governments or financial institutions are in line with the concerns and needs of the private sector. In 2013, the United States President announced the deployment of a national Climate Action Plan which aims to grant the US Global Change Research Program US$2.7 billion of the fiscal year 2014 budget towards the production of climate science and

small and medium-sized enterprises. See unfccc.int/adaptation/nairobi_work_programme/knowledge_resources_and_publications/items/5316.php (Accessed June 28, 2013).

j Other notable examples include Canada's former *Leaders' Forum on Climate Change Adaptation* instituted by the Conference Board of Canada and the *Climate Change Adaptation Project* funded by insurance company Intact.

k Ouranos is one of the main sources of North American regional climate simulations.

information that is directly actionable, including in the private sector.[56]

The operating costs of institutions and forums on climate change adaptation vary depending on whether they simply relay or produce data/information on climate science, impacts and adaptation. The exact benefits to the private sector and the national economies of having in place institutions working on adaptation with the private sector have not yet been comprehensively assessed. However, examples from Canada and the United Kingdom indicate that the return on investment has generally been positive.

For instance, thanks to such institutions private sector actors are able to improve decision-making by taking account of climate change risks and opportunities, as well as enhance the resilience of their operations and value chains. Canadian power utility BC Hydro granted approximately US$800,000 in funding to the Pacific Climate Impacts Consortium (PCIC) over 2007–2010 to answer specific questions about hydro-climate historical trends, regional climate modeling and downscaling, runoff projections for select river basins, and glacier responses to a changing climate. The objective was to feed this data and information into operational and planning models (such as reservoir operations or system optimization models), and inform the development of the company's climate change adaptation strategy. Based on the positive return on investment of working with PCIC, BC Hydro committed an additional US$1.3 million to PCIC over the next four years to expand research into other watersheds and impact areas.[57]

A few examples have shown that government funding granted to institutions or networks on climate change adaptation in the private sector is capable of generating private sector investments for adaptation. For instance, Québec's Ouranos, with its network of 400 scientists and professionals, has benefited from yearly funding in the order of US$10 to 12 million since 2004, CA$3 million of which consists of base program funding from government. The work of Ouranos has generated private sector interest in the form of annual contributions in excess of US$1.6 million each year.[58] This means that for each dollar of base funding from government, Ouranos managed to leverage about 50 cents of private sector contributions and 1.6 dollars of additional project-based public sector funding. With government-funded annual operating costs in the order of US$1.6 million, UKCIP has also managed to leverage private sector funding in support of its work on climate change impacts and adaptation, though the exact amount is not known.[59]

INDICATOR 6: Building and Infrastructure Standards and/or Codes				
Description	**Measures**	**Costs**	**Benefits**	**Business case summary**
Building standards and/or codes incorporating climate change impact and adaptation considerations	▪ National and/or local building standard/code updated to incorporate climate change impact and adaptation considerations (e.g. revised maximum temperature design criteria) and/or building standard/code promoting climate change adaptation practices (e.g. water-efficient design features) ▪ Published plan and/or program to update building standard/code so as to incorporate climate change impact and adaptation considerations	▪ Costs to update building standards and/or codes ▪ Enforcement and training costs ▪ Compliance costs (e.g. additional design/construction costs for new built, and retrofit costs for existing structures)	▪ Improved property value ▪ Avoided loss and damage from climate-related hazards ▪ Lower maintenance and operation costs over time, as well as reduced post-disaster repair costs ▪ Avoided business interruption ▪ Reduced insurance costs	Codes and/or standards increasing resilience against hazards have achieved reductions in loss and damage—American homes complying with new hurricane standards have suffered losses 42% lower on average

All around the world, buildings and infrastructure assets are designed and built using climatic design values derived from historical data.[60] Wind loads, maximum design temperature, snow loads, flood return periods, and rainfall intensity-duration-frequency (IDF) are among the climatic design values most often used in building/infrastructure design and construction; all of these are coincidentally affected by a changing climate.[61] Changes in climate conditions during the useful life of an asset require modifications to how it is engineered, maintained and operated in order to maintain levels of serviceability, safety and costs.[62] In fact, small changes in climate variables have the potential to cause large increases in damage and operation/maintenance costs to existing assets: for example, research by an Australian insurer has shown that each 25% increase in peak wind gust strength above 20 to 25 meters per second can generate a rise in building loss claims of up to 650%.[63]

In many countries structures are designed and constructed following mandatory technical prescriptions contained in standards and/or codes; many of these prescriptions are derived from climatic and seismic design values. As a result, building and infrastructure codes and standards have been identified by governments as an important instrument to increase the resilience of buildings and infrastructure to climate change impacts.[64]

Improving the resilience of the built environment to climate change has become an adaptation priority for many governments around the world, as buildings and infrastructure underpin most, if not all, economic activities.[65] Loss and damage from extreme climate and gradual reductions in performance due to premature weathering of buildings or infrastructure assets have the potential to affect human safety and security, as well as disorganize economic activities. Furthermore, investing today in structures that are not resilient to climate change and are meant to stand for decades equates into sunk costs, as repairs and/or retrofits will be later needed to adapt to changing climate conditions.

A quick look at examples around the world of building and/or infrastructure failures due to weather demonstrates the potential costs of climate change for building/infrastructure owners and managers, if no adaptation is implemented. For instance:

- China's US$4.2 billion railway line connecting Lhasa, Tibet, and Quinghai, China, was built on 'warm permafrost' (commonly defined as permafrost warmer than –1.5°C) thanks to engineering cooling techniques which added 1% to total capital costs,

however if increases in average annual temperature of 2 to 3°C by 2050 are realized in the region, costly retrofits will be needed to ensure the continued safe operation of the railway;[66]

- Research in UK estimated that a section of the main railway line between London and Cornwall will suffer from increased sea wave 'overtopping', as well as more frequent speed restrictions and line closures because of sea level rise and increased coastal flood risk, adding to the already high annual maintenance costs of US$793,000 borne by the railway operator Network Rail;[67] and
- A study by University of Alaska Anchorage showed that without adaptation, the costs of climate change for public infrastructure in Alaska (such as roads, airports, bridges, railroads, harbors, water and sewer systems, buildings and telecommunications assets) could be in the range of US$3.6 to 7 billion between 2006 and 2030, adding 11 to 22% to ordinary wear and tear costs.[68]
- Without codes and standards prescribing engineers and architects to follow building and infrastructure design and construction practices that are resilient to climate change impacts, developers and owners have little incentive to bear the additional upfront costs to adapt, given the uncertain (and sometimes long-term) payback. Even in cases where adaptation practices are not costly, the dearth of awareness and/or knowledge of climate change data/information and associated impacts on the built environment in the engineering profession limit the uptake of adaptation practices. Further, the private sector has only limited leverage over building and infrastructure codes and/or standards as they often are a governmental prerogative (although many voluntary codes or standards do originate in the private sector).

Very few jurisdictions across the world have revised their building and infrastructure codes and/or standards to take account of climate model projections and resilience. In fact, many developing countries are struggling with enforcing *existing* building and infrastructure codes and standards, meaning that they already face an 'adaptation deficit' compared with *today*'s climate conditions. The best examples of efforts in this direction can be found in the developed word.

For instance, analysis and revision of building, plumbing and electrical codes, standards and guides is one of the cornerstone actions for Australia's infrastructure in the country's 2007 *National Climate Change Adaptation Framework*.[69] In fact, Standards Australia released in 2013 the voluntary risk management standard AS 5334 *Climate change adaptation for settlements and infrastructure—A risk based approach*, which offers a systematic approach to apply data/information on climate change variables (e.g. sea level, rainfall, temperature, wind relative humidity, soil components, PH component and brush fire risk) in decisions about settlement and infrastructure planning, approval, permitting, commissioning, design, construction, installation, operation, insurance, maintenance and decommissioning.[70]

Canada's federal environment ministry, together with the Canadian Commission on Building and Fire Codes, is updating and improving more than 6,000 specific climatic design values used in the National Building Code of Canada and in several Canadian Standards Association (CSA) national standards.[71] CSA has since identified that 29 of its 250 infrastructure codes and standards are vulnerable to climate change.[72] In 2010 and 2012, CSA released its first guides to help with the incorporation of data/information on permafrost thawing and changes in rainfall in building infrastructure siting and design.[73] CSA is also working with the Standards Council of Canada

to develop four new standards in support of climate change adaptation in Northern Canada as part of the Northern Canada Infrastructure Standardization Initiative.[74]

Updating building codes and/or standards or developing new ones to incorporate climate change adaptation considerations can be a costly investment. It requires the acquisition of quality observed and projected data on climate-related variables and building/infrastructure performance, as well as modelling work. To achieve expected benefits, training of planning and engineering professionals on new and/or revised codes and standards is also required, together with enforcement resources.

For instance, ongoing work by Canada's Institute for Catastrophic Loss Reduction to analyse the effect of extreme weather events on structural aspects of domestic building construction (e.g. extreme wind, moisture penetration, energy efficiency and mould growth) amounts to US$6.8 million of government funding.[75] US$24 million has also been awarded by Canadian governments to a university for producing improved wind simulations and improving understanding of wind impacts on buildings and structures.[76]

However, the benefits of updating building and infrastructure codes and/or standards potentially outweigh the costs many times over: even if the enforcement of codes and/or standards incorporating climate change adaptation considerations contributes to reducing a small portion of the additional US$9 to 24 billion required worldwide each year to adapt infrastructure to climate impacts, the return of investment is unquestionable.[77] The buildings in New York City that were built to meet the 1983 building code standards on minimum Base Flood Elevation have fared considerably better than buildings that were built before these standards were in place, demonstrating the costs that climate-resilient building codes can help to save in the face of climate change.[78]

In fact, the United States Institute for Business and Home Safety (IBHS) has demonstrated these economic benefits at the building level, taking the example of hurricane damage in Florida. The hurricane losses suffered by homes built according to new 'hurricane-proof' standards decreased by 42%, from an average of US$12 to 24 per square foot, compared with homes built according to older standards.[79] As hurricane intensity could grow stronger in a warmer climate, the same range of benefits can be expected from building codes and/or standards taking consideration future changes in hurricanes, though the existing scientific uncertainty in this area has to be considered.

Further, codes and/or standards incorporating climate change adaptation considerations in building and infrastructure design and construction can create a range of additional benefits from improving human health, safety and well-being, to lowering maintenance and repair costs, enhancing property value and reducing insurance premium costs.

INDICATOR 7: Public Infrastructure				
Description	**Measures**	**Costs**	**Benefits**	**Business case**
Public and/or key infrastructure having factored climate change impacts and adaptation into design, operations and/or decommissioning	▪ Public and other key infrastructure built and/or retrofitted taking account of climate change impacts and adaptation considerations (e.g. use of storm-resistant construction material) ▪ Geographic extent of resilient public infrastructure	▪ Research costs ▪ Design and construction costs for new infrastructure ▪ Retrofit costs for existing infrastructure	▪ Increased government revenue opportunities due to higher attractiveness (e.g. local tax or levies) ▪ Improved property value ▪ Expected project/asset useful life maintained ▪ Avoided loss and damage from climate-related hazards ▪ Lower maintenance and operation costs over time, as well as reduced post-disaster repair costs ▪ Improved user health, safety and well-being ▪ Avoided business interruption	The benefit-to-cost ratio of investing in making infrastructure more resilient to climate change impacts is potentially considerable—based on global estimates by the UNFCCC and the World Bank each dollar spent on adapting infrastructure can save between $4 and $69 each year from 2030 onward

Public and other key infrastructure is essential to private sector activity. For instance, modern, efficient and reliable highways, water treatment facilities and public transit ensure that the private sector reaches its markets, accesses the freshwater that is necessary for its operations, and attracts a qualified workforce. This is why ensuring the resilience of public infrastructure in a changing climate is critical to long-term economic prosperity and social well-being.

Public infrastructure is extremely vulnerable to climate change due to several factors:

- It is designed and constructed based on engineering standards with past climate-related data (except in jurisdictions that incorporate climate change adaptation into infrastructure design codes and standards; see Indicator 6);
- Assets are long-lived (e.g. 15–40 years for power plants to 40–75 years for roads, railways or power distribution networks); and
- Investments create 'sunk costs' whereby new infrastructure locks populations and businesses reliant on it into given lifestyles and economic patterns until the next cycle of asset refurbishment and/or replacement.[80]

The impacts of a changing climate on the built environment will be felt differently across infrastructure assets (based on asset type, age, maintenance and design safety margins) and locations:

- Where assets are exposed to extreme weather hazards (e.g. tropical cyclones or winter storms), increased temperatures will increase the hazard intensity and associated loss and damage;
- In cold regions of the world, warmer temperatures and the associated ice/snow melting and permafrost thawing will increase premature weathering of public infrastructure (e.g. rutting of winter roads, higher rates of erosion, and instability of building foundations);
- In areas of hot weather, increased episodes of extreme heat and more drought cycles will also increase wear and tear of infrastructure assets (e.g. damage to underground pipes due to soil shrinking, reduced depth of navigable waters, and increased indoor temperatures); and
- Infrastructures by the coast or nearby rivers are likely to suffer from increased flood risk.[81]

In a number of developing countries vulnerability to climate change is high because of old and/or poorly maintained infrastructure and low levels of government funding. This means that many countries already suffer from an 'adaptation deficit' in their infrastructure relatively to *current* climate conditions.

It is not always easy to predict how the impacts may affect private sector. Recent examples of companies affected by disruptions in infrastructure services due to abnormal weather events exemplify this:

- Widespread flooding in Australia in 2010 severely disrupted railway networks and port terminals, which in turn shut down market access for the state coal mines, driving down coal export stockpiles at ports and causing severe delays on coal export contracts. Market analysts estimate that floods have stripped US$2.5 billion from the earnings of Australia's mining industry; and
- An extreme rainfall event in Russia in 2012 caused 164 casualties possibly due to poor road design and construction, whereby bridge openings clogged with debris were not wide enough to channel flood waters and avoid destructive water build-up.[82]

Studies by the UNFCCC and the World Bank have placed the additional annual costs needed to adapt infrastructure anywhere between US$8 to 130 billion and US$14 to 34 billion by the 2030s respectively.[83] Overall, the sums required to adapt infrastructure remain a small portion of total infrastructure costs. Further, these sums are considerably lower than future infrastructure damage and loss due to more extreme climate, which ranges from US$850 to 1,350 billion each year from 2030 onward (equivalent to between 1 to 2% of today's GDP).[l, 84] This demonstrates that the benefit-to-cost ratio of investing in making infrastructure more resilient to climate change impacts is very often considerable. If it is assumed that adaptation investments can contribute to avoid half of future damage and loss due to a more extreme climate, each dollar spent on adapting infrastructure can save between US$4 and 69 each year.[m] While these figures do not distinguish between public and from private infrastructure, they do give an indication of how worthwhile investments in building the climate change resilience of public infrastructure are.

More local examples of the economics of adapting public infrastructure for the private sector exist. For instance, New York City has recently deployed a US$19.5 billion plan to build a 'stronger, more resilient New York', which aims to improve the resilience of the city's infrastructure including: coastal zone protections, buildings, utilities, water and wastewater management infrastructures, transportation and telecommunications. This plan comes in response to hurricane Sandy which caused losses worth US$19 billion, including US$6 billion due to reduced economic. Examples of adaptation investments covered by the plan include reconstruction of roads with upgraded design standards, ground elevation of traffic signals and electrical power back-up, improvements in storm water management for future capital projects in the city, and installation of

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l These estimates extrapolate observed increases in weather-related insured losses into the future, and do not capture the costs of premature infrastructure weathering and rising maintenance and repair requirements,

m Using the range of annual climate change adaptation costs for infrastructure of US$8–130 and US$14–34 billion from the UNFCCC and the World Bank respectively, and yearly loss estimates associated with future increased extreme climate from the UNFCC of US$850 to 1,350 billion (all sums are for the 2030s period, except for the World Bank numbers which are for 2030).

floodgates at tunnels.[85] New York City estimates that if the coastal protection measures and major power and building protections recommended in the first phase of its plan are implemented, future expected losses in the 2050s due to weather events could be reduced by up to 25% or more than US$22 billion. Further, New York City could also avoid much of the possible losses associated with a storm like Sandy by the 2050s, which could reach US$90 billion (in current dollars).[n]

Recognizing the vulnerability of its infrastructure to climate-related hazards such as tropical cyclones, storm surges and flash floods, the Federated States of Micronesia (FSM) passed a law to 'climate-proof' the infrastructure, taking into account design values based on climate model projections and not just on climate observations.[86] For instance, FSM intends to design its urban drainage networks to allow heavier rainfall loads during future storms and thus reduce flash flood risk and associated loss and damage. By introducing this law, private sector resilience is therefore indirectly enhanced. A study by the FSM estimating the cost of climate-proofing a road section shows that it is 30% more costly to do so through retrofits rather than at the design and construction stage; however, retrofits to increase climate change resilience remain a cost-effective investment thanks to an internal rate of return of 13%.[87]

[n] Because of projected sea level rise and possible increases in hurricane intensity, this is almost five (5) times as much as the losses caused by Hurricane Sandy.

INDICATOR 8: Local Zoning Rules				
Description	**Measures**	**Costs**	**Benefits**	**Business case**
Local zoning rules incorporating climate change impact and adaptation considerations for new and/or existing infrastructure/buildings in areas vulnerable to climate change (e.g. floodplains, coasts)	▪ Zoning rules with climate change impact/adaptation considerations (e.g. sea level rise estimates, revised flood zones) ▪ Absence of zoning rules promoting maladaptation practices (e.g. reduced coastal protected areas which could increase vulnerability to sea lever rise and rising storm surges) ▪ Zoning rules with climate change impact/adaptation considerations extend beyond individual municipalities and/or councils	▪ Costs to develop and/or amend local zoning regulations ▪ Compliance costs (e.g. siting, design and construction requirements) ▪ Possibly higher capital costs ▪ Enforcement and training costs	▪ Increased government revenue opportunities due to higher attractiveness (e.g. local tax or levies) ▪ Improved property value ▪ Increased revenues thanks to emerging opportunities (e.g. engineering services) ▪ Expected project/asset useful life maintained ▪ Avoided loss and damage from climate-related hazards ▪ Lower maintenance and operation costs over time, as well as reduced post-disaster repair costs ▪ Avoided business interruption ▪ Reduced insurance costs	The costs of developing and enforcing new/amended zoning are outweighed by the protection of developments against rising weather-related loss and damage

Local zoning regroups all the legislative and regulatory tools (e.g. zoning bylaws, zoning codes) through which local authorities control land use within their borders. For instance, zoning bylaws divide communities into zones where restrictions on certain land uses and/or requirements on structures are imposed, including maximum height, lot coverage and density, building type and minimum setbacks. Through zoning rules, local authorities can limit developments in areas prone to climate-related hazards, such as flooding, wildfires, landslides or coastal erosion.

Incorporating climate impact and adaptation considerations into local zoning rules is a powerful instrument to build the resilience of communities and developments against changes in the intensity, frequency and/or duration of climate-related hazards, for instance:

Increasing the number of lots that must be vegetated or made of pervious surfaces helps to manage increased stormwater runoff;

- Creating natural and/or built buffers between the waterfront and developments reduces vulnerability to riverine or coastal flooding; and
- Promoting minimum building basement height above flood levels helps to maintain the costs of flooding down. [88]

Across the world, there are many well-publicized examples where local zoning has been used to promote climate change adaptation, most notably:

- The city of Cartagena in Colombia is the first South American coastal city to release climate change adaptation guidelines that lay down the foundation for forthcoming municipal zoning policies, for example in favor of mangrove habitats that form natural barriers against the impacts of coastal erosion and storm surges;[89]
- Following Hurricane Sandy, New York City released an emergency rule raising minimum elevation requirements for reconstruction of damaged buildings and new developments together with an Executive Order suspending existing zoning restrictions on building height[90]—these regulatory changes are meant to remove barriers to climate change adaptation in the city's floodplains, and to enable building owners

and developers to meet the revised 2013 Base Flood Elevation standards from the United States Federal Emergency Management Agency; and

- In Canada's British Columbia, a group of local governments developed a model 'Climate-resilient Subdivision and Development Servicing Bylaw' that public authorities can use to revise their own zoning regulations in order to incorporate climate change adaptation into process requirements and design specifications for development permit applications.

However, in some cases existing local zoning rules create barriers to climate change adaptation and promote maladaptation practices that increase climate change vulnerability.[91] For instance, the state of North Carolina in the United States passed a law in 2012 banning state agencies from using exponential sea level rise projections for law-making and planning, and requiring them to use linear extrapolations based on historical trends until a state sea level rise study has been completed.[92] This law goes against recent scientific research that has observed local rates of sea level rise in the United States North East coast three to four times higher than the observed global average.[93] Further, in many developing countries, the effectiveness of local zoning rules is constrained by limited capacity to carry out enforcement.[94]

Where there is capacity for enforcing laws and regulations, local zoning can be a cost effective instrument to promote climate change adaptation.[95] Indeed, local governments in areas prone to climate-related hazards have already experimented and developed cutting-edge land use policies and instruments to mitigate these risks. In many cases, these policies can be borrowed and adapted to cope with climate change impacts.[96] The costs of using existing local zoning rules to promote climate change adaptation can be negligible where 'win-win' opportunities exist. For example, this is the case of Milwaukee in the United States, which has in place zoning rules to support green roofs as a measure to manage stormwater; if the city promoted green roofs in areas vulnerable to urban heat islands, it could solve two problems at once without needing additional authority and/or funding.[97]

INDICATOR 9: Permitting and Impact Assessments				
Description	**Measures**	**Costs**	**Benefits**	**Business case**
National/local permitting and/or impact assessment rules incorporating climate change impact and adaptation considerations into developments	▪ Consideration of climate change resilience as part of permitting (e.g. land use and/or construction permits) and/or environmental/social impact assessments ▪ Examples of incorporation of climate change impact and adaptation in national strategic and/or project impact assessments	▪ Costs to develop policies, legislation, regulation and guidance ▪ Compliance costs (e.g. incorporation of climate impacts and adaptation into permit applications and/or ESIAs) ▪ Possibly higher capital costs ▪ Enforcement and training costs	▪ Expected project/asset useful life maintained ▪ Increased revenue opportunities (e.g. consultancy services) ▪ Maintain community performance and social license ▪ Exploitation of 'shared opportunities' between communities and private sector ▪ Avoided loss and damage from climate-related hazards ▪ Lower maintenance and operation costs over time, as well as reduced post-disaster repair costs ▪ Avoided business interruption ▪ Reduced insurance costs	Upfront incorporation of climate change impact and adaptation considerations at the permitting and/or impact assessment stage can result in lower long-term repair, maintenance and replacement costs, and create value—there are several EIA examples showing the rationale for climate-proofing developments

Obtaining development permits° and conducting environmental impact assessments (EIAs) and/or social impact assessments (SIAs) are part of everyday business. For instance, most countries have laws and/or regulations in place requiring some form of EIA for projects potentially harmful to communities and/or the environment. Even where rules on EIAs and SIAs are absent, international financial institutions and large banks often require them as part of investment due diligence.[98] IFC's *Performance Standards on Environmental and Social Sustainability*, which are followed by the 79 project finance banks that are signatories of the Equator Principles, require "a process for identifying the environmental and social risks and impacts of the project", including climate risks.[99]

Traditionally, development permitting and impact assessments have been used to evaluate potential impacts *of* a project *on* the community and the environment and to identify mitigation measures to reduce these impacts to an acceptable level. As such, the consideration of climate change impacts *on* a project and possible adaptation measures to reduce and/or avoid these impacts requires a shift in permitting and impact assessment practices.

With a changing climate, a new set of challenges needs to be considered as part of development permits and impact assessments. First, the impacts of a project may not be fully understood or anticipated if climate change is not considered in its design, for instance if drainage capacity is not capable to cope with future higher rainfall loads. Second, by affecting ambient environmental conditions (e.g. hydrology, land cover, wildlife), as well as community concerns and actions (e.g. flood risk management or ecosystem-based adaptation), climate change can affect the environmental and social performance of projects over time. For example, water-intensive projects in areas that will be affected by reduced surface and/or ground water levels could face unforeseen community opposition if no adaptation measure is implemented to reduce conflict over water use. Third, cumulative impacts on a project may arise due to the actions carried out by those who are affected by climate change impacts (e.g. public authorities, surrounding businesses or communities).

° Development permits are land use planning tools used by local governments to impose requirements on the required information, material or studies needed to evaluate development and/or subdivision applications.

By incorporating requirements favorable to climate change adaptation into development permit applications (e.g. requirement to assess climate risks or requirement to collect rainwater where water is scarce), local governments can prohibit, limit or control the use of natural resources and/or influence siting/construction choices in areas vulnerable to climate change.[100] For instance, Toronto's Green Standard in Canada sets a number of performance measures for municipal developments which contribute to address several climate impact concerns for the city, including: using light-colored construction materials to avoid overheating, installing open-grid pavement to reduce solar radiation and/or water run-off,[p] shading on at least 50% of site areas to reduce the urban heat island effect, and retaining at least the first 5 millimeters of each rainfall event through rainwater collections and/or green surfaces. Similarly, EIAs and SIAs can play a major role in facilitating successful 'climate-proofing' of projects and avoiding maladaptation practices.[101]

Worldwide, several countries have started taking steps to promote climate-resilient EIAs, though most examples are limited to the developed world. For instance:

- In 2005 Scotland passed the *Environmental Assessment Act* which identifies climate change as a transversal factor that needs to be considered throughout Social and Environmental Assessments;[102]
- In Canada, it is a requirement for major development projects to incorporate climate change impacts and adaptation in EIAs; the Canadian Environmental Assessment Agency provides a methodology for considering climate change impacts and adaptation in the EIA process, which has been implemented in a number of projects;[103]
- In 2013, the European Commission published guidance on how to integrate climate change adaptation in EIAs carried out across the European Union, in application of the Directive 2011/92/EU currently under review;[104]
- The Caribbean Community has published operational guidance for EIA specialists on how to integrate climate risk management considerations;[105] and
- The International Association for Impact Assessment organized a series of symposia in autumn 2010 on impact assessments and climate change, aimed at informing impact assessment and infrastructure professionals of ways to consider climate change data/information in EIAs.[106]
- However, even in places where rules exist, the incorporation of climate change impacts and adaptation considerations in impact assessments remains limited, and where it is done, practices vary in quality. For example, the United States Council of Environmental Quality published guidance in 2010 on how to consider climate change in Environmental Impact Statements (EISs) submitted by government agencies. In a review of over 200 EISs submitted under the United States *National Environmental Policy Act* and the *California Environmental Quality Act* researchers from Columbia Law School found that climate change impacts and adaptation receive brief mentions at most.[107] In most developing countries, where EIA rules are either nonexistent or not enforced, climate change resilience is likely a very marginal consideration.

There is much less information about the incorporation of climate impact and adaptation

[p] Open-grid pavement consists of concrete or hard plastic grid systems with large pore spaces filled with a planted growing medium or light colored aggregate (e.g. grave).

considerations in development permitting, given that it is a local prerogative. Certainly a few local examples exist where requirements development permit applications have been amended to promote climate change resilience. For instance, several state agencies oversee different aspects of coastal development permits in New York City; this translates into a long and costly permitting process, which delays the repair and development of waterfront infrastructure important for flood protection. As part of its post-Hurricane Sandy resilience plan, New York City will work with state agencies to develop a 'one-stop' waterfront permitting website.[108]

For project developers, the additional costs of integrating climate impact and adaptation considerations in permit applications and/or impact assessments are likely to be modest, though this will vary from one project to another depending on data collection/analysis needs. Even when costly changes in project design and construction are required to accommodate future climate change impacts, these costs will remain lower than the avoided repair and/or retrofit costs in the case of long-term developments.[109] For those types of projects, it makes sense to make costly investments in adaptation today rather than delay action. In doing so, developers can avoid damaging government and/or community opposition to a project or reduce part or all of the loss and damage associated with future climate change impacts. For instance, mining operations in Chile have learnt to deal with water scarcity through process innovation (e.g. water efficiency, water recycling and use of desalination) and/or trading within water rights exchange markets or with urban water treatment plants. In the Copiapó valley, mining companies purchase water rights from local fruit growers; however this has pushed the price of water rights so high (in the range of US$80,000 to US$120,000 for a liter per second of flow) that it has started causing tensions between mining, farmers and local community groups. As a result, some mining companies may have to start looking at using water from alternative sources, despite the higher cost.[110]

Although only a few, examples of EIAs factoring climate change impacts and adaptation into project design and construction decisions illustrate the business case of promoting climate change resilience at a project-level through impact assessments. For instance, in Australia where there is no federal framework for considering climate change impacts and adaptation in EIAs, the Australian Capital Territory government required the *East Lakes Electrical Infrastructure Relocation Project* to conduct a climate change risk assessment as part of its EIA for the relocation of a 132kV electrical substation, switching station and transmission network.[111] As part of it, modelling of climate change impacts on future flood risk in 2030 and 2070 was conducted. Results led to a recommendation that all electrical equipment at the proposed substation site be positioned approximately two meters above expected maximum flood levels taking account of climate change.

The Confederation Bridge between Canada's provinces of New Brunswick and Prince Edward Island also integrated a climate change risk assessment into its EIA. The US$1 billion project involved the construction of a 27km long bridge designed to permit the passage of ships underneath it. The bridge stands approximately 40 meters above sea level at the side spans and 60 meters above sea level over the main navigation channel. In order to plan for a 100 year design life, the EIA included an assessment of projected sea level rise over this time period. Taking account the associated risks, the bridge was built 1 meter higher than originally proposed and a monitoring programme was established to provide early warning of any unanticipated changes.[112]

INDICATOR 10: Investor Relations and/or Stakeholder Management				
Description	**Measures**	**Costs**	**Benefits**	**Business case**
Incorporation of climate change impact and adaptation considerations in instruments and practices for investor relations and stakeholder management (e.g. disclosure in security fillings/bond prospectuses, stakeholder consultation, or community resettlement and compensation)	▪ Policy and/or legal/regulatory requirements and guidance to consider climate change impacts and adaptation as part of corporate disclosures (e.g. securities filings, other corporate reports), stakeholder consultations, and/or community resettlement or compensation agreements ▪ Implementation of climate change adaptation actions in response to investors and/or stakeholders beyond simple disclosure	▪ Additional costs of disclosure, consultation, resettlement and compensation (e.g. additional research and data/ information) ▪ Costs to implement adaptation in response to stakeholder needs and/or investor requests	▪ Possible credit risk upgrades ▪ Expected project value maintained ▪ Improved investor and stakeholder relations ▪ Potential preferential insurance and financing terms (e.g. longer-term view) ▪ Avoided business interruption	By reducing levels of private sector risk and avoiding costly conflicts with stakeholders/investors and possible credit score downgrades, the benefit-to-cost ratio of incorporating climate change impacts and adaptation into investor relations and stakeholder management is likely to be positive

The private sector is not an island: companies, industry associations and cooperatives rely on their relations with stakeholders (e.g. surrounding community groups, suppliers, customers and insurers) and investors (e.g. shareholders and lenders) to create and sustain value. The impacts of a changing climate can affect these relations if nothing is done to assess and manage potential risks, for instance:

- Companies and cooperatives that fail to take into account the concerns of their investors with regards to climate risks could see their access to capital reduced; and
- Companies that don't pay heed to the vulnerability of surrounding community groups to climate change and their adaptation needs could lose their social license to operate.

Taking a proactive approach on climate change adaptation with stakeholders and investors can also generate new opportunities. For instance, it can help to uncover areas where further engagement with communities can protect and/or increase revenues. It is with this motivation in mind that utility company Entergy in the United States has engaged with some of its customers in Texas and Louisiana to understand the critical infrastructure assets where it is critical to maintain power supply during natural disasters in order to reduce disruptions to socio-economic activity.[113] From this work the company has learned that sewage and water treatment power plants are one of the areas where efforts should be expanded to improve climate change resilience, for example through the installation of power generator backups.[114]

In 2012, United Kingdom coffee and tea distributor Cafédirect ran a competition open to its small-scale coffee and tea producers for climate change adaptation funding. Out of 12 proposals, two suppliers in Mexico and Uganda have been selected to receive a $US15,000 grant to implement actions that improve their resilience, namely: the installation of solar-powered coffee driers and the development of sources of income diversification respectively. Cafédirect stands to win from these measures as they will improve its security of supply of Fair Trade tea and coffee and help to ensure long-lasting relationships with suppliers.[115]

While examples are few, there are several benefits in incorporating climate impact and adaptation considerations into community consultations and resettlement/compensation:

- By affecting ambient conditions, climate change can potentially change the costs associated with providing sustainable living areas, infrastructure and livelihoods in

case of private sector projects requiring population resettlements;[116]

- As a changing climate will aggravate natural resource scarcity in many parts of the world, increased land acquisitions in developing countries could either push populations towards areas facing significant climate risks (e.g. low lying coastal areas or drought-prone areas with poor access to freshwater) or reduce their income over time with the potential to increase social instability (e.g. because of the loss of livelihood resources);[117] and
- Without adequate compensation that takes into account future climate change impacts on community livelihoods and well-being (e.g. agricultural yields), private sector projects could suffer criticisms and/or active opposition from community groups faced with hardship from changing socioeconomic or environmental conditions due to climate change.

Research on recent resettlement programs in Vietnam to protect populations against flood risk demonstrates that without adequate consideration of future climate change impacts and the resilience of sources of livelihoods, resettlement can sometimes fail to reduce climate change vulnerability and/or deteriorate livelihood security in displaced communities.[118]

In some countries, the number of shareholder resolutions linked to climate change adaptation is increasing: it nearly doubled in the United States and Canada between 2010 and 2011.[119] The costs to a company can be multipronged:

- In some cases, addressing shareholder resolutions (whether they are approved by a majority of votes or not) requires undertaking steps to assess climate risks, opportunities and adaptation, and develop adaptation action plans; and
- If they are not dealt with appropriately and they fuel investor concerns on corporate credit worthiness, shareholder resolutions can lead to reduced risk ratings and/or share prices.

Disclosing material risks and opportunities from a changing climate can reassure investors about future growth and risk management, as well as avoid reduced credit/access to finance. Failing to do this, several power water utilities in the United States have already suffered downgrades in the credit risk scores of their bonds based on fears of water scarcity.[120] Other benefits also exist in relation to insurance and lending. Insurers make extensive use of 'defensive underwriting' to deal with climate change risks, from re-pricing insurance policies and applying high deductibles to withdrawing from high risk areas.[121] Private sector actors that demonstrate efforts to manage risks could benefit from reduced insurance premiums and/or other preferential treatment.[122] Furthermore, some financial institutions, such as the IFC and Barclays, have started integrating climate change risk considerations into their investment diligence processes.[123] As these practices develop further and become more common in the future, those who are taking proactive steps to improve their climate change resilience could be rewarded with preferential financing terms.

A number of governments and regulators have recently introduced policies, laws/regulations and/or guidelines for the private sector to promote the incorporation of climate change impacts and adaptation in stakeholder and/or investor relations.[124] This is the case, most notably, of the United States Securities Exchange Commission and the Canadian Securities Administrators (CSA) which published guidance in 2010 to clarify how and what registered companies should disclose with regards to material climate change risks and opportunities.[125]

In the United Kingdom, the 2008 *Climate Change Act* Adaptation Reporting Power requires of operators of critical infrastructure to produce reports on the current and future predicted impacts of climate change and their proposals to adapt to climate change. In the first round of reporting between 2010 and 2011, over 100 public and private organizations, primarily in the energy, transport and water sectors, reported on climate change impacts and adaptation.[126] The costs of compliance have been found to be reasonable for mid- to large-size organizations: conducting a climate risk and opportunity assessment and developing adaptation action plans costs on average US$69,000, and each reporting company adds between US$4,000 and 8,000 in government costs for support and monitoring.[q] These costs are outweighed by the benefits of reduced risk in the private sector (e.g. avoided transport delays from flooding, avoided power outages during extreme climate events and avoided water deficit) and increased government knowledge of how climate change impacts on critical infrastructure influence national vulnerability.[127] For instance, much of the information in companies' adaptation reports was leveraged by the United Kingdom government to inform its *National Adaptation Plan* released in 2013.[128]

[q] These costs may seem high for some SMEs, however there are opportunities for undertaking this work in partnership and sharing the cost burden between different organizations.

INDICATOR 11: Government Incentives				
Description	**Measures**	**Costs**	**Benefits**	**Business case**
Government incentives promoting climate change adaptation in the private sector	▪ Positive direct (e.g. grants, interest-free loans) or indirect (e.g. tax rebates/credits) incentives in support of climate change adaptation (e.g. irrigation, diversification towards climate resilient sectors, relocation towards climate resilient areas) for those private sector actors who need support to adapt, including planning and implementation, purchase of equipment and material, and innovation/R&D ▪ Absence or elimination of government incentives promoting mal-adaptation (e.g. drought/flood relief funds. subsidized insurance)	▪ Amounts of government incentives displacing tax revenues ▪ Administration costs of incentive programs ▪ Increased maladaptation aggravates loss and damage from climate-related hazards, as well as increases maintenance, operation and post-disaster repair costs ▪ Portion of adaptation expenditures not covered by incentives	▪ Increased uptake of adaptation practices reduces loss and damage from climate-related hazards and lowers maintenance, operation and post-disaster repair costs over time ▪ Increased revenue opportunities (e.g. water management and efficiency) ▪ Reduced insurance costs	Incentives can promote mal-adaptation unless they target climate change impacts where market failures prevent cost-effective adaptation; in those cases incentives can improve the Net Present Value of adaptation investments—in Morocco drip-irrigation would not be economically viable with government incentives

Economists have shown that successful adaptation to a changing climate is most likely to happen where goods, services, and production inputs and resources are allocated within competitive markets.[129] For example, farmers have adapted to weather patterns and climate throughout history, and often without policy interventions: as they recognize impacts on yields, they alter their practices (e.g. choice of crops or timing of farming schedules).

Government incentives can be both barriers and enablers of private sector adaptation. Incentives can be a barrier by distorting the price signal of climate change impacts and affecting private assessments of climate change risk levels, which both act to reduce the business case for making adaptation investments. For example, government incentives on production inputs (e.g. seeds or fertilizers) or outputs (e.g. crops) may reduce the incentive to adapt and in turn lock farmers into unsustainable practices. Most notably, there are two areas where government incentives are known to prevent cost effective adaptation decisions: irrigation and drought management, and natural disaster relief.

Many governments worldwide offer incentives to farmers in support of irrigation and/or in reaction to drought losses. However, these programs can sometimes have perverse effects on the climate change resilience of the agricultural sector. For instance, economic modeling work in the United States has shown that the effect of a 25% drop in available irrigation water in California (e.g. due to reduced rainfall and/or increased water demand from other users) could have a limited impact on agricultural earnings (a 6% reduction only) if water prices reflect the level of scarcity and farmers are able to switch their productions towards higher-valued crops. However, with irrigation incentives, delaying action by farmers, agricultural losses can possibly be much higher.[130] In Australia, a review of the National Drought Policy is presently underway. The policy previously included assistance provisions for farmers in areas declared to be under 'exceptional circumstances', such as interest rate incentives, farm exit support packages and small business income support. An inquiry by the Australian government Productivity Commission recommended that these programs are terminated because they prevent farmers from proactively improving their drought preparedness, and that they are replaced with programs promoting a 'risk management' approach to droughts. More specifically, the following incentives have been put

forward by the Productivity Commission and are presently under review by the government:

- Income support schemes designed to take account of individual farm circumstances, available on a time-limited basis, and involving a 'mutual responsibility contract' whereby risk management actions to improve farmers' self-reliance are required; and
- Training and advice to assist farmers to prepare for, manage and recover from the impacts of increased climate variability and long-term changes.[131]

Natural disaster relief is another area where government incentives can potentially prevent climate change adaptation. Australia's Productivity Commission warns that federal *Natural Disaster Relief and Recovery Arrangements* (NDRRA) used to fund part of disaster recovery costs (e.g. assistance to affected individuals and businesses and restoration of critical publicly-owned infrastructure) have the effect of potentially reducing incentives for state and territory governments to manage their residual risks by adopting adequate insurance arrangements.[132] NDRRA may also lower the impetus for states and territories to adequately manage climate risks on public infrastructure given that they do not bear the full cost of post-disaster repairs and reconstruction. New NDRRA clauses were introduced in 2011 requiring states and territories to implement 'disaster-mitigation strategies' and to report on their insurance arrangements to the federal Australian government.[133]

The same 'moral hazard' exists in the private sector. For example, in support of reconstruction efforts post-Hurricane Sandy, the United States FEMA offered economic incentives to some owners for elevating their buildings in compliance with FEMA's revised Base Flood Elevation standards. However, in some areas of New Jersey the height of Hurricane Sandy's storm surge exceeded FEMA's revised standards, and in the absence of government incentives to cover elevation expenditures going beyond US$45,000, some building owners are rebuilding below Hurricane Sandy's flood depths.[134]

However, the use of public incentives in certain situations can leverage private sector investments in climate change adaptation by a certain level of magnitude through a 'crowd-in' effect.[135] Public incentives can be a positive instrument of increased climate change resilience in the private sector, by supporting a range of measures including:

- Climate change impacts and adaptation planning;
- Purchase of equipment and material;
- Implementation of climate change adaptation actions (e.g. construction of new assets, improvements to existing assets, education/capacity-building); and
- Research and development and innovation in the private sector (e.g. water efficient production, stress-resistant crops, storm-resistant construction material).

Government incentives can remediate a market failure and incentivize climate change adaptation practices in the private sector. Two notable examples are:

- Provision of support to particularly vulnerable groups, such as smallholders and SMEs, who are not aware of the risks or do not have sufficient information and/or resources to plan for climate change; and
- Encourage retreat from areas where climate change risks can no longer be managed.

For instance, in Morocco where climate change is expected to reduce available water for irrigation by 16% by 2030, the government provides several types of incentives to farmers implementing water-efficient irrigation

systems. The cost of drip-irrigation systems is subsidized by up to 80%, which generates a positive investment Net Present Value for the average farmer of US$1,465 over 10 years (with a 10% discount rate). Without the government incentive, drip-irrigation investments would not be economically viable.[136] Small-scale farmers with less than 5 hectares of crops can have the full cost of their water-efficient irrigation system covered.[137] These government support programs are part of the Green Morocco Plan which aims to convert 550,000 hectares of farmland to water-efficient irrigation systems in regions where, without incentives, climate change could amount to considerable losses in agricultural output.

As part of their post-Hurricane Sandy reconstruction efforts, New Jersey state officials will use US$300 million to purchase around 1,300 homes in flood prone areas where retrofitting would neither be a sustainable nor an economically-justified solution.[138] On New York Staten Island, where flood risk has been heightened in the 2013 revision of the United States Federal FEMA flood maps, government has offered to buy-out homes for 100% of their pre-hurricane value in the most affected areas.[139] These acquisitions by government are considered one of the most cost-effective flood hazard management measures, as they will avoid future costly insurance claims and dependence on disaster assistance programs should a new flood hit the same area.

The private sector is a direct beneficiary of these incentives, with a twofold effect. On the one hand, they constitute direct gains in the short-term because costs are shared with government. On the other hand, they represent indirect gains in the long-term thanks to the preventive effects of targeted measures. This is particularly crucial for the most vulnerable businesses like SMEs. SMEs typically have a lower financial capability to absorb the upfront capital costs of investing in long-term resilience. Their resilience is therefore enhanced by these incentives.

In light of the costs of recent extreme weather events, there are growing concerns that climate change could add a considerable fiscal burden on governments. In fact, in 2013 the United States Government Accountability Office identified climate change as a high risk threat to government finances.[140] In short, climate change impacts are expected to result in increased fiscal exposure for governments around the world based on their roles as i) owners, operators or financiers of infrastructure/assets, ii) insurers of property, crops and other operations or resources vulnerable to climate change, iii) providers of data, information and technical assistance, and iv) providers of aid relief and budget support in response to natural disasters. In this context, understanding the role that the private sector can play in funding climate change adaptation is critical to relieve some of the burden on governments.[141]

The United States is one of the countries that have already started taking steps to manage the fiscal risk of climate change by changing some of their incentive programs. The *Flood Insurance Reform Act* of 2012 requires government flood insurance rates to rise 25% annually on properties that have repeatedly suffered flooding, and on second homes and businesses, in an effort to redress the National Flood Insurance Program balance sheet which has been considerably damaged by the cost of Hurricane Sandy. Further, no more insurance will be given to properties that are built below the most up-to-date Base Flood Elevation standards, even for building that were up to code when built.[142]

This move comes at a time when the positive effect of subsidized insurance products addressing climate-related hazards is hotly debated around the world. For instance, in countries where flood risk insurance does not exist, the role of government incentives is increasingly

questioned, as private insurers become more aware of future risks and less willing to offer insurance solutions.[143] However, scientists recently warned governments of the perverse effect of subsidized insurance in the United States (e.g. the National Flood Insurance program and state residual property insurance for wind storm damage), among which:

- Distortions in the risk perceptions of property owners;
- Repeated loss claims from high risk properties; and
- Disincentives for relocation of high risk properties to safer areas where it is no longer financially viable to rebuild.[144]

Interestingly, the United Kingdom recently took steps to create an insurance solution for increased flood risk. The country expects to see increased flood costs in the range of US$2.4 to 5.5 billion and US$2.5 to 10.1 billion by the 2020s and 2050s respectively.[145] Recognizing that households in high flood risk areas will economically suffer from future damage and loss and increased insurance premiums, the United Kingdom government and the Association of British Insurers have agreed a Memorandum of Understanding on developing a not-for-profit scheme known as Flood Re that would ensure flood insurance remains affordable and available for those households.[146] Insurance premiums for beneficiaries of Flood Re will be capped, and the facility will benefit from US$285 million annually from the insurance industry (the equivalent of a $US16.6 levy each year on household insurance premiums). The objective is that Flood Re will be able to sustainably deal with at least 99.5% of years; in the 0.5% costliest years, Flood Re will cover insured losses up to those expected in a 1-in-200-year flood event thanks to government funding. Questions have been raised by economists and climate change experts on the financial sustainability of Flood Re in a changing and more volatile climate, especially as estimates of future property under high/medium flood risk fall short of the government's projections in the *Climate Change Risk Assessment*.[147]

INDICATOR 12. FINANCE

Description	Measures	Costs	Benefits	Business case
Public and/or private finance instruments (e.g. loans, equity, guarantees) for climate change adaptation, including planning, implementation, purchase of equipment and material and innovation/R&D, in the private sector	▪ Finance instruments for the private sector (e.g. loans, equity and/or guarantee products) in support of one or several of the following: ▪ Climate change adaptation planning (e.g. risk/adaptation assessments, strategies/plans, consultations) ▪ Implementation actions (e.g. construction of climate resilient assets, improvements to existing assets to maintain/increase asset useful life and/or reduce vulnerability, insurance policy) ▪ Purchase of equipment or material (e.g. cooling, equipment for hydrometeorological monitoring) ▪ Innovation, research and development (e.g. research on stress-resistant crops or storm-resistant building design)	▪ Opportunity cost of investing in climate change adaptation ▪ Transaction and collection costs, and risk of default ▪ Investment risk	▪ Increased investment flows towards adaptation ▪ Increased revenue opportunities (e.g. new investment vehicles and investment markets) ▪ Increased uptake of adaptation practices reduces loss and damage from climate-related hazards and lowers maintenance, operation and post-disaster repair costs over time ▪ Meeting political commitments on climate change adaptation finance	Provision of finance in the amounts necessary and at a competitive cost is critical to successfully promote private sector adaptation – the fact that private financial institutions have started providing capital for adaptation projects/activities demonstrates that revenue opportunities exist

In today's credit-constrained economy the question of climate change adaptation financing is all the more important. In the private sector, climate change adaptation investments compete for capital against other investment priorities with potentially more established and/or higher internal rates of return. Further, adaptation investments are perceived to have uncertain benefits realized over long periods of time.

Different potential sources of finance exist for climate change adaptation. First, at an international level, dedicated investment funds exist to support investments aimed at improving knowledge on climate change vulnerability and risks and building resilience, and a portion of them is open to private sector projects. This is the case of the Pilot Program for Climate Resilience (PPCR) which created a set-aside for the private sector. There are also examples of bilateral climate change adaptation funds for the private sector adaptation, such as Canada's Climate Funds for the Private Sector in Asia and in the Americas. Each fund has its own administrative and institutional requirements, as well as particular funding constraints, which create significant complexity for potential recipients. More often than not these transaction costs are likely to outweigh the cost of other sources of funding in the private sector. Further, the amounts available through international and bilateral funds remain limited compared to the amounts required to adapt (in fact they dropped from US$3.1 to $1.8 billion between 2010 and 2011);[148] however this could change in the next few years.

Secondly, international financial institutions (e.g. IFC, IDB, ADB, EBRD, EIB and AfDB) support private sector organisations on climate change adaptation with a range of financial instruments (debt, equity or guarantees). In the 2011 fiscal year, multilateral development banks reported providing over US$3.6 billion in climate change adaptation finance, a portion of which benefited the private sector.[149] As an example, USAID through its Development Credit Authority offers risk-sharing guarantees to small businesses looking for loans covering up to 50% of default risk; while not dedicated to climate change adaptation some of these guarantees have been used to stimulate private sector investment in measures that reinforce private sector resilience.[150]

Further, a number of private banking and investment organisations have reported providing capital for private sector adaptation

projects or activities. For instance, both Standard Chartered and Swiss Re report supporting farmers affected by extreme weather risk in their risk reduction actions, Credit Suisse support infrastructure resilience investments out of its lending portfolio, and Goldman Sachs offers catastrophe-linked securities to transfer risks from extreme weather.[151] In Bangladesh, over 40% of existing microfinance programs contribute to climate change adaptation in the private sector, with a few examples of microfinance products promoting long-term resilience, such as housing loans for investing in stress-resistant building design and loans for hybrid crop varieties that are tolerant to salt- and water-related stresses. However it is difficult to assess at a sectoral or country level the extent of private capital lending and/or investment in private sector adaptation given the absence of consolidated reporting standard.[152]

Finally, in some countries, government funding is made available to cover all or part of private sector expenses for climate change adaptation. For instance, in the United States builders applying resilient construction practices qualify for up to US$25,000 in tax credits through the *Disaster Savings and Resilient Construction Act* (H.R. 5839).[153]

The Copenhagen Accord agreed in December 2009 set out the shared goal of making available US$100 billion a year by 2020 from developed countries to finance mitigation and adaptation in developing countries. Private sector investment was identified in the Copenhagen Accord as a significant contributor to this financing flow, without being specific as to the mechanisms and the incentives required. In an earlier report in 2007 the UNFCCC recommended a 15% public and 85% private financing split. Despite repeated statements from government on the urgency of climate change adaptation, little progress has been done since 2009 to clarify how investments will be financed.

INDICATOR 13: Full-Cost Accounting for Water and Energy				
Description	**Measures**	**Costs**	**Benefits**	**Business case**
Cost accounting and pricing practices by water and energy utilities reflecting the 'true' lifecyle costs of the impacts of more extreme weather and climate change on water and energy management and services, and thus incentivizing increased efficiency, reduced consumption and improved resilience	▪ Absence or phasing out of subsidized utility prices promoting maladaptation practices ▪ Adaptation measures promoting 'full-cost' accounting of climate change risks for water and energy (e.g. differentiated pricing and smart metering)	▪ CAPEX and OPEX for meters and pricing system overhaul ▪ Transaction costs (e.g. Power Purchase Agreement renegotiation) ▪ Research costs ▪ Enforcement and training costs	▪ Increased revenue opportunities (e.g. demand side management) ▪ Access to alternative and/or additional revenues covering adaptation costs ▪ Better mid- to long-term utility planning and/or pricing decisions enhancing profitability ▪ Increased water and energy efficiency	Measures introducing climate change risks and opportunities into pricing decisions have much potential to improve resilience and utilities across the world are taking steps in this direction

Energy and water are among the sectors most at risk from climate change. Indeed, extreme weather events and incremental changes in climate affect energy generation, transmission and distribution because of higher air and water temperatures, more frequent and intense storms and flooding, and their impacts on infrastructures. Water is also affected because of alterations in the hydrological cycle due to changing climate conditions and saltwater intrusion in aquifers due to rising sea-levels and mismanagement of groundwater. In the meantime, climate change also leads to higher consumption of both water (e.g. increased irrigation) and energy (e.g. increased air conditioning and refrigeration). For instance, events triggered by higher energy demand due to hot temperatures and drought conditions, similar to the Northern India blackout in 2012, could become more frequent. In 2001, drought-induced blackouts in India created total costs of $108 million for business customers.[154]

Further, impacts are compounded by the interdependencies between water and energy. Electricity powers water extraction, processing and delivery, while water is used to generate electricity or to cool installations. In 2003, Électricité de France had to purchase power on the open-market at a much higher price than usual to cope with high peak demand, at a time when many of its power plans were shut down due to regulatory restrictions on water discharge temperature.[155]

The threat of water shortages, power failures, and high water and electricity costs is therefore high for utilities and the rest of the private sector. For instance, it is estimated that European countries like Slovenia, Bulgaria and Romania will see their electricity wholesale prices respectively increase by up to 15%, 23% and 32% for 2031–2060.[156] Water prices are already rapidly increasing around the world: global water tariffs rose by an average of 6.8% between 2010 and 2011 with an average tariff estimated at $2.03/m^3.[157]

The promotion of 'full-cost' accounting for water and energy, and/or the removal of incentives distorting price signals, has the potential to influence the adoption of more resource-efficient appliances and practices, as well as innovation, by taking into account the lifecycle costs of more extreme weather and climate change on utility assets and service provision over time. For instance, in its 2011 Climate Change Adaptation report, UK utility Severn Trent Water took some steps in the direction of 'full-cost' accounting by making commitments to reinforce customer metering and reduce water demand and leakage.[158] Further, a number of gas utilities minimize the occurrence of very high peak demand during colder-than-expected winter months through the use of weather derivatives; research has found that customers of utilities with these practices in place have a lower exposure to very high bills.[159] In the United States, regulators in water-stressed states, such as Texas, California

and Arizona, have implemented 'conservation pricing' that decouples the price of water from the amount used, which generates additional resources for utilities to invest in water efficiency and conservation.[160]

Careful consideration of the impacts of utility practices such as 'decreasing-block tariffs' and 'area-based irrigation tariffs' on climate change resilience is also important in order to avoid promoting maladaptation.[161] For instance, in places where energy and water prices are heavily subsidized, incentives to adopt cost-saving measures and invest in efficient appliances are lesser.[162]

Credit ratings and bond markets are slowly adjusting to the fact that climate change poses considerable utility risks and adds to pre-existing capital needs for infrastructure rehabilitation, all of will reflect on utilities' financial statements and cost structures.[163] As such, 'full-cost' accounting can represent a way for utilities to address investor concerns by improving transparency on the long-term costs of climate change.

INDICATOR 14: Environmental Trading Markets				
Description	**Measures**	**Costs**	**Benefits**	**Business case**
Markets to trade environmental entitlements or allowances (e.g. over water) under pressure from climate change and/or to pay for environmental services which play a role in ecosystem-based adaptation	▪ Markets where entitlements or allowances over water are traded or ecosystem services are paid for (e.g. services associated with afforestation, reforestation or avoided deforestation) ▪ Amounts of entitlements/ allowances traded each year	▪ Administration and enforcement costs (e.g. exchange markets) ▪ Costs of entitlements/ rights (e.g. licence) ▪ Transaction costs	▪ Supports ecosystem-based adaptation ▪ Access to alternative and/or additional revenues for adaptation ▪ Improved allocation , access to and use of environmental resources	Market-based mechanisms offer opportunities to facilitate private sector adaptation—Research on water markets in Australia has validated their climate change resilience benefits

Little work has been done to assess the feasibility and benefits of market-based mechanisms for private sector adaptation. Where reduction of climate change vulnerability requires increased environmental resource use efficiency, markets where entitlements or allowances are traded (e.g. water markets) are a possible solution. Where protection of and/or improvements in ecosystem services[r] are needed as part of ecosystem-based adaptation (EBA)[s] strategies, payment for ecosystem services (PES) schemes[t] can also play an enabling role.

Market-based mechanisms offer opportunities to facilitate private sector adaptation through promoting the efficient use of resources under pressure from climate change and/or by facilitating EBA. In some cases, they also can constitute a source of revenues for climate change adaptation investments.[164] Two market-based mechanisms have shown much potential to assist in private sector adaptation: water markets and PES for afforestation, reforestation and avoided deforestation.

First, increasing pressures on hydrological cycles, most notably changing rainfall patterns, higher ambient temperatures and evaporation, sea-level rise and saline intrusion, are known to affect water resources availability and quality. In this context, water markets have the potential to provide a flexible and adaptive framework to improve water resource management through more efficient allocation. There are not many examples of water markets around the world, however countries such as Chile, Australia and the United States boast successful examples.

For instance, US $3.1 billion worth of water rights was traded in Australia between 2009 and 2010.[165] Further, Australia benefits from water market intermediaries (e.g. brokers and exchanges) who perform a number of important functions to ensure smooth and effective trading, including: finding and negotiating with a trading partner, advising customers on price and water trading rules, and/or completing the necessary paperwork. Research has validated the climate change resilience benefits of water markets in Australia, among which: better agricultural performance during periods of drought, improved water use efficiency, positive impacts on river flows and quality (lower salinity), and increased water resources for ecosystems.[166] More specifically, according to

r Ecosystem services consist of ecological processes or functions having monetary or non-monetary value to the private sector, individuals or society at large (e.g. food, fiber, carbon sequestration, flood protection).

s Ecosystem-based adaptation (EBA) refers to the use of sustainable ecosystem management activities to support climate change adaptation. See CBD 2009.

t Payments for environmental services (PES) refer to transactions where a service provider is paid by, or on behalf of, service beneficiaries for environmental management practices that are expected to result in continued or improved service provision. See www.cbd.int/doc/external/fao/fao-2007-report-en.pdf.

Australia's National Water Commission, access to the Murray-Darling Basin water markets is estimated to have contributed to avoid cumulative gross agricultural production losses worth AU$2.3 billion, AU$760 million and AU$419 million in the states of Victoria, New South Wales and South Australia respectively between June 2006 and November 2010. Revenues generated by the sales of water allowances have also led to improved adaptive capacity; for example, dairy farmers in Northern Victoria and New South Wales have used part of the income generated by their sales of water allowances to purchase additional fodder (as a strategy to manage reduced on-farm pasture production).[167]

Chile has also experimented with water market systems since 1981, with a number of benefits, among which: reduction in water use of 26 and 70% between 1975 and 1992 in the agricultural and wood pulp sectors, and improved water efficiency in the mining sector.[168] However, serious adjustments to water market governance are sought in Chile to improve equitable access to water resources, notably for poor farmers.[169]

Second, PES can reduce climate change vulnerability in the private sector in three fundamental ways, for instance by:

- Protecting and/or enhancing the provision of ecosystem services that are known to reduce exposure and/or sensitivity to climate-related hazards (e.g. using mangroves for coastal protection against sea level rise and higher storm surges);
- Improving the adaptive capacity of PES sellers (e.g. increased revenues and knowledge); and
- Incentivizing practices that build climate change resilience (e.g. forest conservation to receive payments, and which protects against accelerated soil erosion).[170]

In Costa Rica, observed increases in rainfall intensity have been blamed for higher rates of soil erosion and siltation in rivers where hydropower facilities are sited. As a result, watershed conservation upstream of hydropower plants is seen as a climate change adaptation measure supported by PES.[171]

In a few instances, other market types have been used to leverage capital for private sector adaptation. This is the case in Peru where coffee farmers have raised funding for climate change adaptation from the sale of carbon credits obtained from reforestation projects in coffee plantation areas vulnerable to flash floods and soil erosion which are phenomena amplified by climate change.[172]

INDICATOR 15: Information and Communication Technologies				
Description	**Measures**	**Costs**	**Benefits**	**Business case**
Availability and market penetration of information and communication technologies (e.g. internet and mobile cellular)	▪ Country area with internet coverage and/or mobile phone reception ▪ Internet and/or mobile cellular usage	▪ Acquisition and use of ICTs ▪ Possibly higher capital costs	▪ Improved access to data/information for climate change adaptation ▪ Better mid- to long-term planning and/or pricing decisions enhancing profitability ▪ Increased revenue opportunities (e.g. ICT services)	International bodies have acknowledged the role of ICTs for private sector adaptation – examples of pilot ICT projects, for example CocoaLink in Ghana, demonstrate the value of ICTs to protect and create value for SMEs and small-holders

Information and communication technologies (ICTs) are important pre-requisites for socio-economic prosperity. They also play an important role in enabling climate change adaptation and ensuring resilience to extreme weather and long-term climate change.

Today's two main and most effective ICTs are the internet and mobile cellular phones, and their reach does not stop at developed nations. The penetration rate of mobile cellular reaches 79% in developing countries. Mobile broadband coverage (i.e. access to internet via a mobile device) is also increasing rapidly, with 90% and 45% of the world's population benefiting from 2G and 3G network coverage respectively. In 2011, 62% of worldwide internet users were in developing countries, with about half of that percentage in China and India alone. It must be noted that mobile phones are often the only method of telecommunications available to the private sector in developing countries, where telephone landline infrastructure remains spotty.[173]

The importance of ICTs for climate change adaptation has been acknowledged by international bodies: for instance the UNFCCC indicates that ICT tools "can be critical in predicting, identifying and measuring the extent of climate change; as well as in the development of effective response strategies to adapt to negative effects of climate change in sectors such as agriculture, employment, technology transfer and energy."[174] Their potential for supporting private sector adaptation ranges from facilitating access to learning and exchange within and between economic sectors and strengthening decision-making processes by integrating up-to-date climate data/information and/or traditional knowledge, to supporting livelihood diversification.[175]

A large number of the data/information and tools supporting adaptation decision-making are only available for consultation and/or download through the internet and/or mobile cellular. This is true of most of the global climate change adaptation resources made available by international and donor organizations for the private sector.[u]

At the national level, some government agencies and research centers have also made available online and through mobile cellular applications data/information and tools to support private sector adaptation. For instance, the UK Climate Impact Program *Adaptation Wizard* is an online tool that supports private sector organizations in developing climate change adaptation strategies and plans.[176] The U.S. National Climate Data Center has made available online and for free weather and hydroclimate datasets and other resources, including digital maps that can be manipulated by users.[177] In Nepal, the website of the Department of Hydrology and Meteorology is expected to evolve into a more

[u] For example the IPCC Data Distribution Centre, the World Bank *Climate Change Knowledge Portal*, the International Institute for Sustainable Development *Community-based Risk Screening Tool* (CRiSTAL), the Global Adaptation Institute *GAIN Index*, WWF's *Water Risk Filter*, the Ceres *Aqua Gauge*, and the GEMI *Local Water Tool*.

extensive digital library of climate-relevant data/information for all important socio-economic sectors of Nepal, including downscaled climate model projections, evaluation and monitoring products and tools, and management information systems providing farmers with critical and timely agro-climate and weather information.[178] [179]

In Ghana, CocoaLink, an innovative and free mobile data-sharing service by the Hershey Company, the Ghana Cocoa Board and the World Cocoa Foundation, provides cocoa farmers with early-warning alerts on weather and soil conditions, as well as information on farming best practices via SMS and voice messages. CocoaLink aims to introduce data/information on climate change impacts and adaptation, as well as reach 100,000 farmers in Ghana by 2014 and expand into the Ivory Coast.[180] In doing so, it intends to build the resilience of farmers against extreme weather and climate change.[181]

INDICATOR 16: Technology and Knowledge				
Description	**Measures**	**Costs**	**Benefits**	**Business case**
Access to and use of technology and knowledge useful to understand, assess and response to climate change risks and opportunities	▪ Prevalence of technologies with climate change adaptation benefits ▪ Participation in knowledge and/or transfer projects ▪ Integration of climate change impact and adaptation considerations in school and professional training curriculums	▪ Technology R&D, commercialization and acquisition ▪ Intellectual property right protection ▪ Education, training and capacity-building	▪ Improved access to data/information for climate change adaptation ▪ Better mid- to long-term planning and/or pricing decisions enhancing profitability ▪ Increased private sector revenues (e.g. engineering or consultancy services) ▪ Promotion of innovation	Access to specific technology and knowledge is required to adapt in many cases – because of the associated revenue and cost saving opportunities such investments can have high positive Net Present Values

Access to and use of specific technologies and knowledge is required to effectively understand and respond to climate change adaptation challenges. There is no set definition of what technologies or knowledge contribute towards climate change adaptation in the private sector, as it is highly context-specific, however some stand out as playing an important role in reducing vulnerability and building resilience, for instance:

- Stress-resistant crops;
- Crop yield and pest management;
- Water desalination;
- Off-grid water supply (e.g. rainwater collection, solar- and wind-powered water pumping and water treatment);
- Remote energy supply (e.g. decentralized solar-, wind- or hydro-power generation, solar heating and cooking);
- Efficient lighting;
- Dispersed electricity transmission (e.g. high voltage direct current with lower power loss rates compared with alternative current);
- Climate resilient power transmission and distribution (e.g. underground power cables, and structures/elements resilient to water, moist or corrosion); and
- Weather prediction and early-warning (e.g. remote sensing and satellite technologies for analyzing and monitoring hydro-meteorological and biophysical impact variables, and mobile phone applications).[182]

International collaboration on technology and knowledge development and transfer is primordial to promote climate change risk management and resilience. Yet, a lot of improvement is needed in this area. For instance, there is very little co-invention activity on pro-adaptation technologies between developing and OECD countries.[183] The UNFCCC, the United Nations Development Program (UNDP) and the Global Environment Facility (GEF), among other international organizations, seek to promote technology and knowledge transfer relevant to climate change adaptation, however funding for these activities has remained very limited. Between 2006 and 2011, only US$15.1 million out of a total of US$142.6 million of pledged funds for climate change adaptation (the equivalent of 10%) have been dedicated by the GEF Special Climate Change Fund to technology transfer projects.[v, 184]

[v] Taking into account co-financing from other institutions, these technology transfer investments amounted to a total of US$32.6 million out of total climate change adaptation pledges worth US$986.2 million (the equivalent of 3%). See http://www.thegef.org/gef/sites/thegef.org/files/documents/sccf-vol1.pdf.

Overall, developing countries suffer from a reduced capacity to develop or access technology, which contributes to constrain the ability of their private sector to assess and manage vulnerability to extreme weather and climate change. For instance, between 1980 and 2009, inventors from African countries created a very small number of patented technologies with climate change adaptation benefits ('pro-adaptation' henceforth).[w, 185] More specifically, in the case of biotechnology patents (e.g. drought-, saline or heat-resistant crops), technology transfer to developing countries has remained extremely limited.[186] Furthermore, most of the pro-adaptation technologies patented in Africa originated predominantly in OECD countries. However, it is encouraging that the rate of 'pro-adaptation' technology inventions patented in Africa has grown by as much as 17% yearly on average, and 'pro-adaptation' inventions from Africa tend to be protected relatively more often with African patent offices than anywhere else in the world.[187]

Successful technology transfer does not just stop at the development and acquisition of technology, but also requires the transfer of know-how and skills to use, operate, maintain and understand technology.[188] One of the critical indicators for successful technology and knowledge transfer in support of climate change adaptation in developing countries is the number of scientists, engineers and other types of experts (e.g. planners, specialists in insurance and micro-insurance) able to effectively and efficiently implement adaptation measures.[189] Investments in institutions (e.g. universities, schools, R&D laboratories) and education/training programs covering subject matter issues relevant to national adaptation concerns (e.g. hydro-climatology, drought or flood modeling, water resource management, soil erosion, sustainable building engineering and management) are important levers so that the private sector is able to access the best available technology and knowledge for decision-making. Such investments are currently much inferior to what is needed. Yet, there are many opportunities for integrating subjects relevant to climate change adaptation in school/university programs, either through the introduction of new course or the insertion of new material.[190] For example, in Cameroon while some aspects of climate change adaptation issues are already present in primary, secondary and university-level education programs, there are scarce to no references to climate change risks, vulnerability or adaptation in education syllabi.

A few worldwide examples demonstrate the value of investing in the integration of subject matter issues relevant to climate change adaptation (e.g. hydro-climatology, impact modeling, risk-based decision-making and policy-making) in school and professional training curriculums. The Australian government Climate Change Adaptation Program has committed US$2.1 million to fund tertiary education, training institutions and professional associations to revised or develop professional development and accreditation programs for architects, planners, engineers and natural resource management with climate change adaptation skills.[191] Examples of dedicated post-graduate degrees on climate change adaptation have also started to emerge across the world with the ambition of building technical capacity on climate change vulnerability and adaptation management tools and techniques.[192]

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w 0.26% of worldwide pro-adaptation technologies were invented in Africa between 1980 and 2009, with a slightly larger share for desalination technologies (0.41%). See Hascic, I., Silva, J., and Johnstone, N., 2012. *Climate Mitigation and Adaptation in Africa: Evidence from Patent Data*. OECD Environment Working Paper. ENV/EPOC/WPCID/RD(2012)1. Paris: Organisation for Economic Co-operation and Development.

6

Piloting the Index Framework in Three Countries

To shed light on how countries with different levels of socio-economic development and climate change vulnerability perform in promoting climate change adaptation in the private sector, and understand what elements may be missing for the enabling environment of private sector adaptation, Bangladesh, Vietnam and the United States have been selected as pilots for applying the Index Framework.

Overview

Bangladesh

Bangladesh is among the world's most vulnerable countries to climate change by virtue of its location at the tail end of a large delta with exceptionally high peak flows, its exposure to monsoons and tropical cyclones, and its levels of socio-economic vulnerability.[193]

For many, Bangladesh is well ahead of many other Least Developed Countries to deal with the impacts of climate change. However, despite considerable attention from donors and numerous local adaptation projects on the ground, much progress remains to be done to increase the resilience of the country's population, economy and natural habitats to a changing climate.

The application of the Index Framework confirms that Bangladesh has a number of favorable conditions in place to promote adaptation in the private sector, though there are many opportunities for improvement: well-established government and research institutions, a reasonable amount of data/information useful to planning and decision-making, and a number of economic incentives. This is in large part a result of the amount of international aid received by Bangladesh. Between 2003 and early 2013, Bangladesh attracted 7% of international funding earmarked for climate change adaptation.

However, the country lacks policies and in-country technology and knowledge to support climate change adaptation in the private sector (see Figure 2). These results are in line with recent stocktaking assessments on climate change adaptation in Bangladesh.[194]

Vietnam

With one of the world's longest coastlines, a large population density at the fringes of two large river deltas (the Mekong River and Red River deltas) and a severe exposure to extreme climate-related hazards (e.g. typhoons and floods), Vietnam is highly vulnerable to climate change.[195] As such, building climate change resilience is important for the prosperity of the country's private sector, especially given the importance of climate-sensitive sectors to national GDP. For instance, agriculture represents 21%, 48% and 12% of the country's GDP, workforce and exports respectively in 2012, though this is slowly being taken over by high-tech manufacturing.[196]

Overall, Vietnam has many of the necessary conditions to enable and promote climate change adaptation in the private sector:

- The amount and quality of available data/information is reasonably good;
- A number of institutions have a mandate to work on climate change impacts and adaptation;
- Some progress is being made in some provinces, districts and municipalities to adopt pro-adaptation policies;
- Economic incentives have been trialed and put in place in different areas; and
- The level of ICTs and in-country knowledge and technologies favorable to climate change adaptation practices is relatively good.

However, much improvement can be made to create a more enabling country environment for climate change adaptation in the private sector, for instance:

- Making data/information available in formats that can be readily used for strategic and operational decision-making in the private sector (e.g. digital data, web-GIS maps);
- Clarifying and/or extending the mandates of existing institutions with regards to supporting climate change adaptation in the private sector;
- Putting in place national- and local-level policies removing obstacles/barriers and/or creating drivers for private sector adaptation and investing in public enforcement capacity;
- Scaling up available finance for climate change adaptation investments in priority regions and sectors, making use of market-based instruments to promote efficient water use and removing government incentives that promote maladaptation practices; and
- Investing in internet broadband infrastructure to enable climate change adaptation.

United States

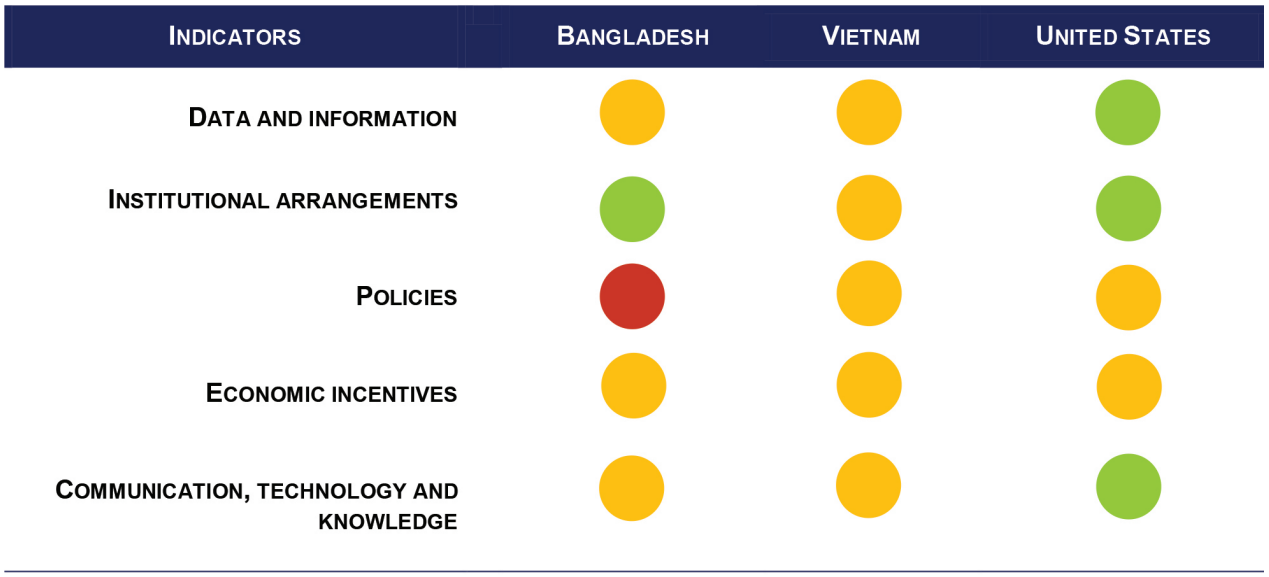
The United States possesses most of the elements of a favorable enabling environment for private sector adaptation. There are extensive amounts of quality data/information about climate, hydrology and sectoral impacts, as well as tools and resources to assist in climate risk and adaptation assessments and adaptation planning. The country also counts several reputable institutions and forums working with the private sector on issues related to climate change impacts and adaptation. Access to technology and knowledge playing a role in climate change adaptation is high; in fact the United States is a major exporter of technology, knowledge and finance for adaptation in the developing world.

However, a number of barriers remain, among which the absence of comprehensive policies and economic incentives. Across the country, there are a number of policy initiatives at the municipal or state level in favor of climate change adaptation, but they remain too few and heterogeneous. Further, despite being a wealthy country, economic incentives for private sector adaptation are lacking and, in fact, large amounts of government incentives promote maladaptation practices in certain economic areas (e.g. the agricultural and energy sectors).

By committing to a number of policy changes, the 2013 federal Climate Action Plan creates a momentum for climate change adaptation, however it includes little in the way of raising adaptation finance of the order that is required to maintain the country's prosperity in a changing climate. These results are consistent with recent assessments of the current state of climate change adaptation in the United States.[197]

Further explanations about these country results are provided in the paragraphs below.

FIGURE 2: Overview of the Current State of Indicators of Enabling Environments for Private Sector Adaptation in Three (3) Pilot Countries



Data and Information

Bangladesh

There is a relatively good amount of data and information useful to private sector adaptation in Bangladesh. Downscaled climate projections for Bangladesh, based on the regional climate model PRECIS, are available to users for free from government. Further, projections are available electronically for a range of primary and derived climate and hydrological variables.[198]

Data/information on future impacts, most notably flooding and agriculture have been produced and disseminated to national users, and case studies of Bangladeshi private sector organizations that have taken adaptation actions have also been compiled thanks to donor support. The World Bank's Economics of Climate Adaptation study has produced climate-related loss/damage and adaptation estimates, which can serve as a basis for understanding the potential costs and benefits of adapting.[199]

Thanks to donor support, a large number of community-based assessments on climate change vulnerability, risk and adaptation are available.[200] Bangladesh has also adopted a National Climate Change Strategy and Action Plan in 2009 which clarifies the areas of vulnerability/

risk and the priorities for integrating adaptation into policies, plans and programs.[201]

Vietnam

Thanks to donor support, and building on the hydrometeorological modeling capabilities of the Institute of Meteorology, Hydrology and Environment (IMHEN), a considerable amount of data/information has been generated on observed trends in climate and hydrology and hydro-climate projections over Vietnam. This includes high resolution climate model projections using dynamic and statistical downscaling techniques.[202] Further, this scientific knowledge has been well disseminated to in-country stakeholders, most notably through the publication of official national climate change scenarios.

Considerable work has also been done to understand a number of direct (e.g. coastal flooding and saline intrusion) and indirect impacts (e.g. crop yields) from climate change.[203] Among the country's economic sectors of importance, fisheries, agriculture and infrastructure have received considerable funding and attention on the issue of climate risk and adaptation. Data/information about community vulnerability, adaptive capacity and adaptation needs is particularly good thanks to work by the World Bank, the Asian Development Bank, USAID and other bilateral development agencies and international non-governmental agencies.

However, most of this data/information can only be accessed through reports, and little is available in raw format or in a format that is ready-to-use for private sector decision making (e.g. maps overlaying data and that can manipulated by users, applications enabling users to graph data). Other than through the websites of international NGOs or initiatives (e.g. the Asian Cities Climate Change Resilience Network and the Asia Pacific Adaptation Network), there is no central database and/or website with data/information relevant to climate risk and/or adaptation.

United States

Despite the absence of official national climate model projections and climate change adaptation cost estimates, there is an excellent level of data/information available on climate, hydrology, future impacts and adaptation in the United States.

Thanks to specialized government agencies, such as the National Oceanic and Atmospheric Administration (NOAA), most of this data/information is freely accessible online and in various formats (from raw data to integrated map applications where data can be manipulated). One of the particularities of the United States in this regard is the availability of tools and other resources for specific climate-related impacts and sectors: for example, the University of Arizona's New Mexico Agroclimate webtool helps to evaluate the effect of the El Niño-Southern Oscillation (ENSO) on agricultural indicators;[204] the National Climate Data Centre released in 2011 the new 1981–2010 U.S. climate normals for use in energy load forecasting and building design standards;[205] and the Environmental Protection Agency *Climate Ready Water Utilities Toolbox* guides users through a risk and adaptation assessment process.[206]

Across the country, hundreds of cities and counties and close to twenty states have started a climate change adaptation planning process, which is one instrument to engage with the private sector and identify areas where resilience improvements can be made.[207]

Though work is needed to improve the consistency and quality of studies on climate change adaptation costs and benefits in the United States, a recent stocktaking review identified a large number of state-wide and local estimates, especially for coastal zone, infrastructure (especially water resources, transportation, telecommunications and structures) and energy sectors.[208]

INDICATOR 1: Climate and Hydrological Projections			
Measures	**Bangladesh**	**Vietnam**	**United States**
▪ Free access to data/information from a national or international body (e.g. government department, public agency, research center, donor organization)	Projected rainfall and temperature available for free from the Climate Change Cell (CCC)	Climate change scenarios (temperature, rainfall and sea level rise) published in 2009 by the Ministry of Natural Resources and Environment (MoNRE);[209] an update is expected in 2015 The World Bank's *Economics of Climate Adaptation* study uses two additional climate change scenarios representing the extremes of the distribution tail of climate moisture indices[210]	Large amount of data/information freely accessible from the National Oceanic and Atmospheric Administration (NOAA), including: ▪ Global climate station data ▪ Global hourly data using station and radar data ▪ High resolution monthly and seasonal climate forecasts ▪ Monthly climate reports and analysis reports[211] ▪ Observed and analysis climate data is also available through NOAA's National Climatic Data Center The Third National Climate Assessment (2013) includes long-term climate model and hydrological projections from Global and Regional Climate Models There are no official national climate model projections
▪ Data available electronically	Data available on CCC website[212]	Data available on the IMHEN website[213]	Data is available on the NOAA's Climate.gov and National Climatic Data Center websites[214]
▪ Data available in both raw format as well as maps or graphs (e.g. cumulative frequency distributions)	Data available as maps and graphs[215]	Data available in a report format (i.e. in tables and maps)[216]	Gridded data is available in raw format, as well as in maps, graphs and tables[217] Gridded data can be manipulated through integrated map applications using web-GIS (Geographic Information System) technology, and accessible via mobile cellular
▪ Downscaled projections	Downscaled climate projections for Bangladesh using the PRECIS Regional Climate Model are available for temperature and rainfall for three time periods (2030s, 2050s and 2070s), one greenhouse gas emission scenario (SRES A2) and the boundary conditions of one Global Circulation Model (ECHAM4)	Downscaled climate projections by Vietnam's Institute of Meteorology, Hydrology and Environment (IMHEN) using the PRECIS Regional Climate Model thanks to United Nations Development Program (UNDP) funding and assistance from the United Kingdom Met Office[218] Statistically downscaled climate change projections for Vietnam using the MAGIC/SCENGEN software[219] Further work in progress to improve downscale projections at the provincial and community levels[220]	Under the North American Regional Climate Change Assessment Program, high resolution projections using a set of Regional Climate Models driven by different Global Climate models have been produced for Canada, the United States and Northern Mexico[221] Climate and hydrological projections using two downscaling techniques for the United States are available from the Coupled Model Intercomparison Project Phase 5 (CMIP5); these will feed into the new projections for the upcoming Intergovernmental Panel on Climate Change[222]
Data available for primary (e.g. average, maximum and minimum temperature and precipitation) and derived (e.g. growing season length, hot/cold days, flood/drought indicators, soil moisture) hydro-climate variables	Data for both primary (e.g. precipitation and temperature maps) and derived (e.g. drought risk and storm surge maps) variables	Data for primary (e.g. mean temperature and rainfall changes) and derived (e.g. coastal flooding at different sea levels) variables available in the official MoNRE climate change scenarios[223] Simulations of future tropical cyclone tracks and intensity based on PRECIS Regional Climate Model projections are also available[224]	On NOAA's Climate.gov website primary and derived data is available, for example: temperature, rainfall, snowfall and indices (e.g. Palmer Drought Severity Index, Heating and Cooling Degree Days)[225]

INDICATOR 2: Direct and Indirect Impacts			
Measures	**Bangladesh**	**Vietnam**	**United States**
▪ Data/information about direct and indirect climate change impacts including flood risk maps, surface/ground water hydrographs, fire hazard indices, rainfall intensity-duration-frequency curves	Flood risk maps by the Institute of Water Modeling based both on observations and climate change scenarios	The World Bank's *Economics of Climate Adaptation* studies a range of climate change impacts including: crop yields, crop irrigation, land area vulnerable to coastal flood risk per land use type, risk of saline intrusion, tree plantation productivity, and macro-economic variables (e.g. household consumption, value added by sector and regional GDP)[226] The *Climate Change Impact and Adaptation Study in the Mekong Delta* provides maps on projected coastal inundation, saline intrusion, significant wave weight due to storm surges, water surface elevation and currents due to typhoons[227]	Data/information on several direct climate change impacts is available from NOAA, for example: ▪ Seasonal climate outlooks ▪ Seasonal hurricane outlooks The National Integrated Drought Information System looks after the U.S. Drought Monitor which blends data and expert judgement into risk maps about current drought conditions and future drought impacts updated every week[228]
▪ Data/information tailored to the needs of different sectors/locations/sizes (e.g. growing season length for the agricultural sector, Heating/Cooling Degree Days for the building sector)	Information for the agricultural sector on impacts and adaptation published by the Bangladesh government and international organizations	The *Climate Change Impact and Adaptation Study in the Mekong Delta* analyses climate change vulnerability and risk for the socio-economic, agriculture, livelihoods, urban settlements, transport, energy and industry sectors[229]	NOAA published specific climate data/information for the following sectors: agriculture, forests and forest ecosystems, civil infrastructure, construction, coastal hazards, energy, health, insurance, litigation, marine and coastal ecosystems, national security, tourism, transportation and water resources[230] Sectoral data/information and tools on climate change impacts is also available from a number of research groups in the United States for example: University of Arizona's New Mexico AgroClimate[231]

INDICATOR 3: Adaptation Measures, Costs and Benefits			
Measures	**Bangladesh**	**Vietnam**	**United States**
▪ Data/information about climate change adaptation measures and associated costs and benefits, including measures such as flood protection, irrigation and water/energy efficiency (e.g. cost-benefit analyses)	Information on climate-related damage/loss and adaptation costs available for the agricultural and transport sectors The CCC e-library contains data/information about adaptation solutions relevant to Bangladesh's business sector (e.g. innovative farming practices, crop insurance)	The World Bank's *Economics of Climate Adaptation* study uses a macroeconomic model to assess climate change adaptation costs and benefits for agriculture (e.g. R&D and irrigation), aquaculture (e.g. water pumping) and coastal ports (e.g. sea walls, surface drainage and infrastructure maintenance/replacement)[232] International research organization WorldFish analyzed the economics of climate change adaptation in aquaculture in the Mekong River delta, more precisely for two export productions: striped catfish and tiger shrimp	No national level analysis of costs and benefits exists Some information is available at the sectoral level, but it does not explicitly identify the portion of future costs and benefits for the private sector and methods of cost estimation vary widely[233] Coastal zones, infrastructure and energy are the sectors where there is the most information on costs and benefits; California and New Mexico have state-wide cost estimates for one or more sectors[234]
▪ Case studies of climate change adaptation in the private sector	Private sector adaptation case studies from the construction, fisheries and agricultural sectors compiled by international organizations	Examples of autonomous climate change adaptation to observed climate variability have been reported in shrimp and catfish farming in the Mekong River delta (e.g. upgrading river and sea dikes, and water pumping)[235] The Food and Agriculture Organization (FAO) assisted the Ministry of Agriculture and Rural Development (MARD) in promoting grazing and fodder grass production in slope lands in Northern Vietnam that increase the resilience of farming income[236]	▪ Seven companies are collaborating on climate change adaptation within the Partnership for Resilience and Environmental Preparedness[237] ▪ 12 out of 100 examples of private sector initiatives on climate change adaptation reported by the UFCCC Private Sector Initiative are from the United States[238]

INDICATOR 4: Community Vulnerability, Risk and Adaptation			
Measures	**Bangladesh**	**Vietnam**	**United States**
National/local climate change vulnerability/risk and adaptation assessments (e.g. reports and/or resource centres)	National Adaptation Program of Action (NAPA) (2005) The Bangladesh *Climate Change Strategy and Action Plan* (2009) The Action Research for Community Adaptation in Bangladesh, a program of community-based adaptation supported by several not-for-profits, has supported a large number of community vulnerability/risk and adaptation assessments Bangladesh hosted the 2013 Conference on Community-based Adaptation to Climate Change[239]	The World Bank's *Social Dimensions of Adaptation to Climate Change* identifies areas of social vulnerability and levels of adaptive capacity in selected sub-regions of the country and population groups[240] The *Climate Change Impact and Adaptation Study in the Mekong Delta* analyses climate change vulnerability and risk for two provinces: Kien Giang and Ca Mau[241] The USAID-funded *Adaptation and Resilience to Climate Change* study assess impacts and adaptation for rural populations in ecologically sensitive areas of the Lower Mekong Basin[242]	15 states have completed their climate change adaptation plans and four states are in the process of doing theirs[243] Hundreds of cities and counties have created Climate Action Plans, many of which make climate change adaptation recommendations (CAP)[244]

Institutional Arrangements

Bangladesh

Adaptation in Bangladesh benefits from the support of a dedicated government organization: the Climate Change Cell of the Department of Environment.[245] While its objective is to provide dedicated climate change services to government departments and agencies, the data/information and guidance that is generated can be used for private sector adaptation.[246] In addition, there are a number of research centres in Bangladesh with well-established expertise in climate-related issues, most notably the Institute of Water Modeling and Bangladesh Centre for Advanced Studies. This, in turn, positions Bangladesh as one of the developing countries with the most institutional capacity on climate change adaptation.[247]

Vietnam

Several national government departments are involved in climate change impacts and adaptation, including the Ministry of Natural Resources and Environment (MoNRE) and the Ministry of Agriculture and Rural Development (MARD), and coordinated under a *National Target program to Respond to Climate Change*. The country also benefits from hydro-climate modelling capabilities in the Institute of Meteorology, Hydrology and Environment (IMHEN) and implementation capacity from the National Institute for Science and Technology Policy and Strategic Studies (NISTPASS) and the Institute of Policy and Strategy and Natural Resources and Environment (ISPONRE). Further, a number of consultancies in the country offer assistance to the private sector on climate change impacts and adaptation. Work from these institutions has benefited a number of economic sectors, most notably agriculture, fisheries and infrastructure, including small- and medium-sized enterprises (e.g. in shrimp, crab and catfish farming industries).[248]

However, overall, there is no single institution, other than IMHEN for hydro-climate data, which holds resources to support the private sector in taking action on climate change resilience.

United States

The private sector in the United States has access to a large range of public and private institutions that offer data/information and support services on climate change impacts and adaptation, including state-of-the-art climate and hydrological datasets (observed and modeled), impact and adaptation assessments,

tools, technical expertise, and information on technology useful to climate change adaptation. Further, the 2013 federal *Climate Action Plan* has announced a number of initiatives aimed at creating and/or improving existing partnerships and forums addressing climate change adaptation.[249]

In addition, co-operation between federal government agencies within the Interagency Climate Change Adaptation Task Force is introducing changes in federal policies, programs and asset management that are likely to influence private sector practices, for example through procurement.[250]

INDICATOR 5: Institutions and Forums			
Measures	**Bangladesh**	**Vietnam**	**United States**
▪ National government and/or private body, consortium or network with a role in facilitating private sector adaptation, including: ▪ Dialogue between the private sector, government, civil society and academia about about issues and needs; ▪ Production and dissemination of data/information relevant to the private sector (e.g. case studies, costs and benefits, best practices); and ▪ Capacity-building and support services to understand issues and implement actions	Climate Change Cell (CCC) of the Department of Environment with the role of "strengthening the capacity of professionals, practitioners, policy makers to reduce unacceptable risks and improve preparedness for climate change impacts" Well-established research centers, including the Institute of Water Modeling and Bangladesh Centre for Advanced Studies. Climate change adaptation case studies for the agricultural and infrastructure sectors available online CCC provides advice to government and other interested parties	The National Institute for Science and Technology Policy and Strategic Studies (NISTPASS) and the Institute of Policy and Strategy and Natural Resources and Environment (ISPONRE) coordinate and assist a number of climate change adaptation activities in the country, among which a scoping assessment and an assessment of climate change impacts[251] IMHEN generates and distributes data/information on climate, hydrology and direct impacts[252] MoNRE hosts the National Target Program to Respond to Climate Change, the government's response to climate change MARD established the *2008–2020 Action Program Framework for Adaptation to Climate Change in the Agriculture and Rural Development Sectors* MoNRE and MARD have carried out sectoral climate change adaptation work[253] Well-established research centers work on climate change adaptation together with international groups, for example the Center for Natural Resources and Environmental Studies of the Vietnam National University or the Institute for Water Resources and Planning A number of boutique consultancies work on climate change adaptation in Vietnam[254]	NOAA, and its network of National and Regional Climate Data Centres, offer state-of-the-art climate and hydrological data/information products to the private sector The Global Change Research Program (GCRP) produces useful data/information for private sector adaptation, including National Climate Assessments and sectoral studies[255] The Interagency Climate Change Adaptation Task Force regroups over twenty (20) federal agencies to develop actions that strengthen the resilience of federal policies, programs and assets to climate change; in doing so, it influences private sector practices (e.g. through procurement and/or policies)[256] The Water Partnership is a public-private partnership that aims to address water challenges around the world; while not directly focused on climate change adaptation, some of its actions contribute to improve the resilience of the private sector (e.g. increasing efficiency and productivity of water use or improving water governance)[257] The 2013 federal Climate Action Plan announced: ▪ A public-private partnership with the healthcare industry to identify and implement measures that ensure the resilience of the medical system ▪ Discussions with insurers and stakeholders about best practices to manage climate risks within industry processes and investment, and incentivize policy holders to take steps to reduce their vulnerability[258] ▪ The development of a 'Toolkit for Climate Resilience' that provides access to existing resources and tools that can be used to manage sea-level rise, storm surges and stormwater[259] ▪ US$2.7 billion in the federal 2014 budget to establish a public-private partnership to explore risk and catastrophe modeling, and develop information and tools for decision-makers[260] Several research centers across the country work with the private sector on climate change adaptation, and a number of private consultancies provide specialized advisory services on adaptation for the private sector[261]
▪ Multisectoral private sector audience	Activities on agriculture, infrastructure and fisheries	A number of reports with case studies are available online through the IMHEN website[12]	Most economic sectors are covered by the work of existing institutions/forums addressing climate change adaptation issues
▪ Participation of and/or benefits to SMEs	No specific mention of SMEs by the CCC or BCCRF	No (or very few) specific initiatives for SMEs	No (or very few) specific initiatives for SMEs

Policies

Bangladesh

Despite some progress since the 1990s, including the commitments in the 2009 *Climate Change Strategy and Action Plan* to mainstream climate change resilience in food security, social protection, health and infrastructure, only one sectoral policy includes climate change adaptation considerations: the 2005 *Coastal Zone Policy*. It prescribes that "efforts shall be made to continuously maintain sea-dykes along the coastline as first line of defense against predicted sea-level rise" together with "an institutional framework for monitoring/detecting sea level rise"; however the Ministry of Water Resources does not clarify how this will be implemented in practice.[263] There is little to no mention of future climate change impacts and adaptation in the country's cornerstone policies and plans with a natural sensitivity to climate, such as the National Water Policy and Management Plan, the National Environmental Management Action Plan, the National Land Use Policy and the National Forest Policy.[264]

The country's building codes and standards do not take account of adaptation, except for a few updates in progress on rainwater and energy management.[265] The collapse of the Rana Plaza building in Dhaka in April 2013 is a reminder that building design and maintenance practices in Bangladesh remain very poor, let alone in view of the impacts of a changing climate.

Although building climate change resilience into infrastructure is one of the six pillars of the 2009 Bangladesh Climate Change Strategy and Action Plan and that funds from the Bangladesh Climate Change Resilience Fund are dedicated to it, little is known about progress in reducing the vulnerability of infrastructure in the country.[266] The World Bank's estimates of the costs to adapt infrastructure in Bangladesh provide an indication of the amount of work that remains to be done: adapting road networks, railways, river embankments, drainage systems and erosion control measures to higher flood risk would require additional investment costs in excess of US$2 billion (about 2% of the country's GDP in 2008–12) and annual recurrent costs of US$54 million.[267] The country's underdeveloped energy system constrains economic activity significantly: only about 40% of households nationwide have access to electricity, biomass remains one of the main sources of energy in rural areas including for village and home-based microenterprises, and the population suffers from unreliable power supply. In a 2011 World Bank survey, 80% of rural households report daily power outages and 60% report significant power fluctuations, due to inadequate generation capacity and the practice of load shedding.[268]

There is no evidence that climate change impact and adaptation considerations are integrated in permitting, impact assessments and stakeholder management in Bangladesh, despite well-publicized examples of community opposition to private sector operations in South Asia due to fears of natural resource scarcity and pollution.[x]

Vietnam

Policies incorporating climate change impacts and adaptation considerations are either limited in scope (geographic and sectoral) or inexistent in certain areas (e.g. national coastal management and community resettlement). However some progress is being made in a few provinces, districts and municipalities that benefit from donor support and are 'leading

[x] For instance, Coca Cola's bottling plants in India faced community opposition based on fears that corporate use of freshwater will further deplete and pollute scarce water resources. This prompted a worldwide adaptation response by the company. See http://caringforclimate.org/wp-content/uploads/Business_and_Climate_Change_Adaptation.pdf.

the pack'. For instance, Ho Chi Minh City's *Climate Change Adaptation Strategy* plans to introduce local zoning changes to reduce climate change vulnerability, and some provinces have started incorporating climate change impacts and adaptation into integrated coastal management zone strategies. One of the challenges with using policy instruments to promote climate change resilience is the poor local enforcement capacity.

The policy area where Vietnam has had the most success in promoting climate change resilience is perhaps the infrastructure sector, more specifically transportation: at least 12 provinces out of 58 have benefited from investments in resilience. For instance, the Asian Development Bank supported at least two investments in climate resilient transportation infrastructure in the country worth US$220 and 76 million investments (e.g. Central Mekong Delta transport connections and 300 kilometers of provincial roads in northern mountainous provinces respectively).[269]

Though much improvement has been achieved in increasing energy supply reliability, Vietnam's power sector remains highly vulnerable to disruptions due to a number of factors, among which: a fast-growing demand, low generation reserve margins and a high reliance on imports.[270]

United States

Across the country, a number of municipalities, counties, states and professional associations have adopted standards, codes, laws or regulations, published guidance, or made improvements to their infrastructure assets to build in climate change resilience. Notable examples include New York City's post-Hurricane Sandy resilience plan and zoning rules, the Army Corps of Engineers' sea level rise guidelines, the Securities Exchange Commission guidelines on corporate disclosures, and the Council for Environmental Quality's guidance for Environmental Impact Statements.[271] Further, the 2013 federal *Climate Action Plan* also calls for a number of policy improvements in support of climate change adaptation including updating building and infrastructure standards and incorporating climate change impacts and adaptation into land use planning.[272]

However, a number of policies create obstacles to climate change adaptation in the United States. For instance, North Carolina adopted a law that forbids state agencies to use exponential sea level rise projections for lawmaking and land use planning, and across the country some existing local permitting and zoning rules may prevent investments in important adaptation measures, such as 'hard' flood defences.[273] On the other hand, due to the fairly developed state of local zoning and enforcement, there are plenty of 'low cost' opportunities to leverage existing laws and regulations for climate change adaptation, for example by targeting urban greening initiatives in areas vulnerable to overheating and/or stormwater issues.[274]

While the United States posesses one of the world's most reliable power systems, there has been an increase in the number of costly power outages caused by extreme climate-related events in recent years, which has put into question the security of the country's power supply.[275]

INDICATOR 6: Building and Infrastructure Standards and/or Codes			
Measures	**Bangladesh**	**Vietnam**	**United States**
▪ National and/or local building standard/code updated to incorporate climate change impact and adaptation considerations (e.g. revised maximum temperature design criteria) and/or building standard/code promoting adaptation practices (e.g. water-efficient design features)	Building codes/standards do not take climate change into account	Building codes/standards do not take climate change into account[276]	The United States. Army Corps of Engineers requires to consider projected sea level rise across the lifecycles of civil works projects[277] Several states and cities have adopted standards or updated their codes, for instance: ▪ Portland (Oregon) updated the city code to require on-site stormwater management for new developments and re-developments[278] ▪ California's building standards mandate water efficiency savings and the state Adaptation Plan calls for a 20% reduction in per capita water use[279] ▪ The Federal Emergency Management Agency (FEMA) released its new minimum Base Flood Elevation standards for New York City, which the City's building code requires building owners to follow in FEMA-designated flood zones as a condition to participate in the National Flood Insurance Program[280]
▪ Published plan and/or program to update building standard/code so as to incorporate climate change impact and adaptation considerations	Update of the National Bangladesh Building Code in progress with two new chapters: 'Energy efficiency and Passive Energy Design Features' and 'Rainwater Management', but no mention of other climate-related aspects	Unknown	The federal Climate Action Plan mentions that the National Institute of Standards and Technology will update buildings and infrastructure guidelines to make them more resilient[281]

INDICATOR 7: Public Infrastructure

Measures	Bangladesh	Vietnam	United States
▪ Public and key infrastructure built and/or retrofitted with climate change impacts and adaptation considerations in mind (e.g. use of storm-resistant construction material)	Funds from the Bangladesh Climate Change Resilience Fund are dedicated to repair, maintenance, adaptation and improvement of infrastructures Climate change resilience in infrastructure is one pillar of the Bangladesh *Climate Change Strategy and Action Plan* (2009), but little is known about progress in reducing infrastructure vulnerability to climate change	The *Climate Adaptation Strategy* for Ho Chi Minh City outlines infrastructure measures regarding flood protection, water storage and drainage capacity, salinization and heat stress[282] Climate change resilience works on transportation connections in six (6) northern mountainous provinces (covering over 300 kilometers of priority provincial roads)[283] The Asian Development Bank (ADB) plans on funding projects to improve access to climate resilient urban infrastructure in Dong Hoi, Hoi An and Sam, including: protection against flood, erosion and salt intrusion; and implementation, construction and/or upgrade of waste water and solid waste collection systems and facilities[284] *The Project for Building Disaster Resilient Societies in Central Regions of Vietnam* aims to enhance community disaster management through storm and flood protection infrastructure[285] The ADB invested US$220 million to support the construction of transportation infrastructure to connect the central provinces with Ho Chi Minh City and Bangkok, and supported a parallel climate vulnerability and adaptation assessment to inform the project detailed engineering design[286]	The U.S. Department of Transportation (DOT) Climate Adaptation Plan for implementation in 2013 seeks to increase the resilience of infrastructure against higher temperatures, severe weather and precipitation, sea level rise and the combined impacts of these changes[287] New York City's resilience plan post-Hurricane Sandy plans to deploy US$19.5 billion to improve the resilience of coastal zone protections, buildings, utilities, water and wastewater management infrastructure, transportation and telecommunications[288] New York's Metropolitan Transportation Authority announced that it plans on raising US$125 million by selling catastrophe bonds to private investors to cover the costs of future natural disasters[289] Across the country, there are a few project examples in this area: ▪ New Jersey Transit Corporation is studying cost effective adaptation strategies to maintain current and planned transit services in a changing climate[290] ▪ The Federal Highway Commission supported five (5) vulnerability and risk assessments on road transportation assets[291]
▪ Geographic extent of climate resilient public infrastructure	Unknown	At least twelve (12) provinces out of 58 have benefited from investments in climate resilient infrastructure	No consolidated information is available

INDICATOR 8: Local Zoning Rules			
Measures	**Bangladesh**	**Vietnam**	**United States**
▪ Zoning rules with climate change impact/adaptation considerations (e.g. conservation of coastal wetlands for flood protection)	2005 *Coastal Zone Policy* mentions maintenance of sea dykes as response to sea level rise, however Ministry of Land's recent Coastal Land Zoning Project (2011) does not take account of climate change[292]	The Ho Chi Minh city climate change adaptation strategy plans to use zoning to encourage new developments in areas resilient to climate change impacts, and to develop and enforce land use regulations to increase municipal stormwater water storage capacity[293] Integration of climate change impacts and adaptation into land-use zoning recommended by the International Fund for Agricultural Development (IFAD) but not implemented yet[294]	Post-Hurricane Sandy, New York City released an emergency rule to raise minimum elevation requirements for buildings and an Executive Order suspending zoning restrictions on building height[295] Several municipalities have zoning rules in place that can be used to promote climate change resilience[296]
▪ Absence of zoning rules promoting maladaptation practices (e.g. reduced coastal protected areas which could increase vulnerability to sea lever rise and rising storm surges)	Unknown	Local zoning is generally weak and/or not enforced, for example in Ho Chi Minh a review of the city spatial master plan found that "it is unclear which zones are protected to what level and what is expected of developers when building in specific zones"[297]	A North-Carolina law bans state agencies from using exponential sea level rise projections for law-making and land use planning[298]
▪ Zoning rules with climate change impact/adaptation considerations extend beyond individual municipalities and/or councils	2005 *Coastal Zone Policy* is of a national scope, but does not create mandatory requirements	Vietnam lacks a sound national coastal policy[299] A number of provinces have started incorporating climate change impacts and adaptation considerations into integrated coastal zone management strategies	The 2013 federal Climate Action Plan makes references incorporating climate change impacts and adaptation into local land use planning

INDICATOR 9: Permitting and Impact Assessments			
Measures	**Bangladesh**	**Vietnam**	**United States**
▪ Consideration of climate change resilience as part of permitting and/or environmental/social impact assessments	Unknown	The level of rigor in identifying and assessing climate change impacts as part of EIAs remains poor[300]	The Council for Environmental Quality published non-binding guidance in 2010 for federal agencies on how to analyze climate change in Environmental Impact Statements (EIS)[301] The Department of Interior issued guidance requiring all its bureaus to include climate change analysis in their EIS and Resource Management Plans[302] The Forest Service issued guidance with basic concepts and practices for considering climate change impacts on proposed projects[303]
▪ Examples of incorporation of climate change impact and adaptation in national strategic and/or project impact assessments	Unknown	Unknown	Environmental Impact Statements from federal agencies only make brief mentions of climate change impacts and adaptation[304]

INDICATOR 10: Investor Relations and/or Stakeholder Management			
Measures	**Bangladesh**	**Vietnam**	**United States**
▪ Policy and/or legal/regulatory requirements and guidance to consider climate change risks and opportunities as part of corporate disclosures (e.g. securities filings, other corporate reports), stakeholder consultations, and/or community resettlement or compensation agreements	Unknown	Absence of government requirements to incorporate climate change impacts and adaptation considerations into resettlement programs A number of resettlement programs in response to severe flooding events have not adequately considered future climate change risks and opportunities and the resilience of sources of livelihoods[305]	The Securities Exchange Commission clarified that registered companies need to report on their material climate change risks and their adaptation responses[306] The National Association of Insurance Commissioners runs an annual voluntary survey on climate change risks and opportunities; responses are analyzed by the not-for-profit organization Ceres[307] The number of shareholder resolutions on climate change impacts and adaptation has doubled between 2010 and 2011[308]

Economic Incentives

Bangladesh

Bangladesh attracted around 7% of the world's approved climate change adaptation funding between 2003 and early 2013, though almost all of it was for its public sector. Private sector projects on adaptation are potentially eligible for funding from the Pilot Program for Climate Resilience and the Bangladesh Climate Change Resilience Fund.[309] However, there is little to no evidence that this has been leveraged by the private sector for adaptation beyond small-scale projects.

Government incentives exist for irrigation (diesel- and solar-powered water pumps, but there is no information about other forms of government incentives in support of private sector adaptation.[310] Reasonably high levels of government incentives in Bangladesh, such as flood relief or incentives for agricultural fertilizers, could have the potential to deter adaptation.[311] As a result, repeated calls have been made to create dedicated incentive programs encouraging adaptation solutions known to address Bangladesh's climate change challenges, such as cyclone resistant housing (up to US$200 million).[312]

Bangladesh possesses the world's largest microfinance industry, with over 1,200 certified microfinance institutions and 13 million clients, 80% of which are below the poverty line. The OECD found that over 40% of existing microfinance programs in Bangladesh contribute to climate change adaptation in the private sector. There are also examples of microfinance products in the country specifically promoting long-term resilience, such as housing loans for investing in stress-resistant building design or finance for hybrid crop varieties that are tolerant to salt- and water-related stresses. BRAC, country's second largest microfinance institution, created a permanent disaster preparedness and climate change department.[313]

Water and energy prices are regulated.[314] More specifically, energy prices are heavily subsidized thanks to a number of government price adjustment programs which create barriers to resource efficiency and resilience: in 2012 incentives for petroleum products and power totaled US$3.4 billion in 2012, the equivalent of almost 1% of the country's GDP.[y, 315] Pilot projects are attempting to introduce smart prepaid meters to reduce today's high levels of power loss and unpaid utility bills.[316]

[y] Based on 2011 Gross Domestic Product of US$112 billion, see World Bank, 2013. *World Development Indicators*. Available at http://data.worldbank.org/data-catalog/world-development-indicators (Accessed 07/09/2013).

Despite water scarcity issues, there is no official trading market for water rights. However, informal water markets for irrigation have developed since the expansion of tube well irrigation. In recent years, these markets have started moving towards a model whereby owners of irrigation equipment (e.g. shallow tube wells and water pumps) enter into deals for irrigation services with nearby farmers and are remunerated through fees per hour of tube well operation.[317]

Vietnam

A number of economic incentives for climate change adaptation in the private sector have been trialed and implemented in Vietnam, from insurance schemes to revolving loan funds. While many of the country's incentive programs support actions that contribute to reduce climate change vulnerability in the private sector, a few of them have the potential to promote maladaptation (e.g. agricultural incentives for seeds, fertilizers and irrigation water). Further, a number of dedicated funds for climate change adaptation in the private sector have been put in place, among which the Support Program to Respond to Climate Change (SP-RCC), the Canadian Climate Change Fund for the Private Sector in Asia, and the Asian Cities Climate Change Resilience Network revolving loan fund for Da Nang.[318]

Despite these economic incentives, a few gaps remain: namely, the absence of water trading markets to deal with drier dry seasons and wetter wet seasons, and the lack of incorporation of climate change risks and opportunities into utility cost accounting.

United States

While a number of existing government incentives play a favorable role for private sector adaptation at the federal and state level, by either supporting vulnerable groups with insufficient information and/or resources to adapt (e.g. incentives to elevate buildings for flood prevention) or by helping populations retreat from high risk areas (e.g. land acquisition programs to compensate building owners in high flood risk zones), many create perverse incentives for maladaptation practices. For example, this is the case of some irrigation and energy incentive programs which reduce incentives for resource efficiency and/or investments in more resilient assets and/or practices (e.g. switching to alternative crops and/or investing in renewable energy generation).[319]

More specifically, in the water and energy utility sectors, although there is some progress being made to incorporate climate change risks and opportunities into strategic and operational plans, much remains to be done to improve resilience.[320]

Despite having one of the highest GDP per capita in the world, the United States has suffered from a lack of comprehensive, coordinated and sustained multi-year climate change adaptation funding.[321] Budgetary constraints in government and competing demands on capital in the private sector are and will continue to be significant barriers to private sector adaptation in the years to come, unless innovative ways to raise finance emerge. Examples of such financial innovations for adaptation are starting to surface in the United States: for example, New York City's Metropolitan Transportation Authority announced that it plans on raising US$125 million to transfer the risk of future climate-related disasters by selling catastrophe bonds to private investors.[322]

INDICATOR 11: Government Incentives			
Measures	**Bangladesh**	**Vietnam**	**United States**
▪ Positive direct (e.g. grants, interest-free loans) or indirect (e.g. tax rebates/credits) incentives in support of climate change adaptation (e.g. irrigation, diversification towards climate resilient sectors, relocation towards climate resilient areas) for those private sector actors who need support to adapt, including planning and implementation, purchase of equipment and material, and innovation/R&D	Government plans to invest US$800 million over 20 years to support the installation of 19,000 solar-power irrigation pumps Government flood relief totaled US$7.6 million in cash and housing grants in 2007	Government has introduced in 2011 a national public-private partnership insurance pilot scheme for crops, livestock and aquaculture (with incentives worth between 20% and 100% of premium cost) to compensate for losses due to natural disasters or epidemics[323]	The *Flood Insurance Reform Act* of 2012 requires government flood insurance rates to rise 25% annually on properties that have repeatedly suffered flooding, and on second homes and businesses; no more insurance premiums will be given to properties that are built below the most up-to-date Base Flood Elevation standards[324] New Jersey and New York state officials have granted incentives to help poor affected homeowners with the costs of reconstruction and building elevation[325] State and federal governments have property acquisition programs in place to compensate owners for retreating away from areas of high flood risk[326]
▪ Absence or elimination of government incentives promoting mal-adaptation (e.g. drought/flood relief funds)	Bangladesh subsidizes diesel costs for farmers relying on diesel-run water pumps for irrigation Most of the budget of the Ministry of Agriculture is spent on incentives for agricultural fertilizer	Vietnam has many incentive programs for agricultural inputs such as seeds, fertilizers and irrigation water	Reconstruction incentives post-Hurricane Sandy have a perverse effect because they are tied to FEMA's Base Flood Elevation standards rather than to the height of Sandy's storm surge[327] Large amounts of agricultural incentives (e.g. for irrigation) potentially prevent cost effective adaptation[328]

INDICATOR 12: Finance			
Measures	**Bangladesh**	**Vietnam**	**United States**
▪ Finance instruments for the private sector (e.g. loans, equity and/or guarantee products) in support of one or several of the following: ▪ Climate change adaptation planning (e.g. risk/adaptation assessments, strategies/plans, consultations) ▪ Implementation actions (e.g. construction of climate resilient assets, improvements to existing assets to maintain/increase asset useful life and/or reduce vulnerability, insurance policy) ▪ Purchase of equipment or material (e.g. cooling, equipment for hydrometeorological monitoring)	$50 million in grants and $60 million in concessional loans approved for Bangladesh under the Pilot Program for Climate Resilience (PPCR) in 2010[329] US$170 million in grants from the Bangladesh Climate Change Resilience Fund (BCCRF)[330] by 2012, supporting adaptation measures such as: research for climate-resilient cultivars, development of climate resilient cropping systems, adaptation against drought, floods, storm surges and tropical cyclones, adaptation in fisheries and livestock sectors, risk management against loss of income or property, improved energy efficiency in production and consumption of energy, energy and water efficiency in built environment, afforestation and reforestation program, renewable energy development	Support Program to Respond to Climate Change (SP-RCC), a multi-donor partnership for climate change investment in Vietnam, is currently valued at over US$200 million per annum with 55% dedicated to private sector development (agriculture, forestry, industry, transport)[331] The Asian Development Bank invested US$585 million in climate change adaptation in 2011, a portion of which benefited Vietnam's private sector[332] The Canadian Climate Change Fund for the Private Sector in Asia managed by the ADB aims to leverage up to US$300 million of private sector investment in climate change, including resilience[333] The Asian Cities Climate Change Resilience Network set up a revolving loan fund in Da Nang which will offer credit through the Women's Union to 400 households by the end of 2014 for investments in storm-resistant housing refurbishments and/or reconstruction[334]	No (or very few) specific private sector finance instruments for climate change adaptation In 2013, the Government Accountability Office identified climate change as a high risk threat for federal government finances
▪ Finance for climate change adaptation targeted at small and medium sized enterprises	Over 40% of existing microfinance programs in Bangladesh contribute to climate change adaptation in the private sector, with a few examples of microfinance products promoting long-term resilience, such as housing loans for investing in stress-resistant building design and loans for hybrid crop varieties that are tolerant to salt- and water-related stresses BRAC, the second largest microfinance institution in the country, created a permanent disaster preparedness and climate change department	The newly established US$95 million SME Fund constitutes a potential platform to support climate change adaptation investments	No (or very few) specific finance instruments for climate change adaptation by SMEs

INDICATOR 13: Full-Cost Accounting for Water and Energy			
Measures	**Bangladesh**	**Vietnam**	**United States**
▪ Absence or phasing out of subsidized utility prices promoting maladaptation practices	Water and energy prices are regulated Government incentives for petroleum products, electricity, natural gas and coal are relatively high compared to other developing countries (equivalent to 5.1% and 7% of national GDP in in pre- and post-tax respectively or about US$13.5 billion in 2011)[335]	Energy prices are regulated, with government incentives amounting to US$5.2 billion in 2011 (equivalent to about 3.4% of its GDP); this is known to be a cause of low energy efficiency[336] Sectoral reform is ongoing to deregulate the electricity market Water is subsidized through low tariffs[337]	Though not much information is available, the United States is known to have high levels of post-tax incentives for petroleum products, electricity, natural gas and coal (equivalent to 3.3% of national GDP or about US$500 billion in 2011)[338] Energy and water utility bond issuers rarely factor in climate change and face the risk of credit score downgrades due to climate change risks[339]
▪ Adaptation measures promoting 'full-cost' accounting of climate change risks for water and energy, including supply-side (e.g. water-efficient cooling) and demand-side (e.g. differentiated pricing and smart metering) actions	Pilot projects are attempting to introduce prepaid smart meters for electricity[340]	96% of water connections in urban centers is metered, however rural households rely mostly on wells[341] Electricity tariffs vary depending on consumer types and time-of-day[342]	▪ Progress is being made in the energy sector to deploy supply-side technologies that are less vulnerable to climate change and more extreme climate; this includes reuse of hydraulic fluids to reduce freshwater withdrawals, condensing cooling towers, dry-cooling systems[343] Efforts are underway throughout the country to reduce peak energy demand from end users through the promotion of energy efficiency and the installation of green and white roofs[344]

INDICATOR 14: Environmental Trading Markets			
Measures	**Bangladesh**	**Vietnam**	**United States**
▪ Markets where entitlements or allowances over water are traded or ecosystem services are paid for (e.g. services associated with afforestation, reforestation or avoided deforestation)	There is no officially functioning water market where rights are traded. However, informal water markets for irrigation do exist	No existing water trading market	▪ Water trading is used in several states where freshwater resources are scarce including Arizona, California, Colorado and New Mexico[345] ▪ Several water markets have in place 'water banks' allowing market players to store water in reservoirs or underground aquifers for future use and/or for trading[346]
▪ Amounts of entitlements/ allowances traded each year	N/A	N/A	▪ There is considerable activity on water markets in the Western states of the United States: 4,407 water market transactions were recorded between 1987 and 2009[347]

Communication, Technology and Knowledge

Bangladesh

Overall, Bangladesh suffers from poor access to information and communication technologies (ICTs) that play a role in enabling adaptation: on average, only 5% and 56% of the population use the internet and have mobile cellular respectively.[348]

Bangladesh has benefited from a number of knowledge and technology transfer projects thanks to donor funding: from capacity-building and training on climate modeling, to promotion of adaptation solutions, such as early warning systems and floating agriculture.[349]

Vietnam

Overall, the country possesses a good ICT network infrastructure: on average, each person has more than one mobile cellular subscription, rates of internet subscriptions are relatively high for a developing country (though broadband access remains poor).

Over the years, Vietnam has benefited from a range of programs aimed at transferring knowledge and/or technologies important to climate change adaptation from training on hydro-climate modeling to capacity building on coastal management and local development planning.

There has been much activity in-country to generate knowledge and technologies capable of reducing climate change vulnerability and building resilience in the private sector, especially with regards to aquaculture and agriculture which represent important economic activities in rural areas and for the country as a whole. There is some evidence to show that this has already translated into improved adaptive capacity in some areas of Vietnam's private sector.[350] Interestingly, across the country select schools and professional training programs have also started to update their curriculums to incorporate material on climate change impacts and adaptation.

United States

The United States benefits from an extensive ICT network, and it is among the centers of excellence for pro-adaptation technology and knowledge. For instance, the country counts a large number of the climate models used in the Coupled Model Intercomparison Project Phase 5 for the upcoming IPCC Sixth Assessment Report, and it is home to a number of private sector organizations that have publically reported making investments in climate change adaptation.[351]

INDICATOR 15: Information and Communication Technologies			
Measures	**Bangladesh**	**Vietnam**	**United States**
▪ Country area with internet coverage and/or mobile phone reception	Internet: 110 operators with nationwide coverage[352] Mobile phone: 6 main operators with nationwide coverage[353] E.g. 'Pacific Bangladesh Telecom Limited' network coverage (internet and mobile phone): 89.6%[354]	Four main internet service operators operate in Vietnam[355] Over 70% of communes have public internet access points and 100% of schools and universities are connected to the internet[356] Seven main mobile cellular service providers operate in Vietnam and ensure nation-wide coverage[357] All mobile cellular operators offer 3G services, however market penetration remains low[358]	Extensive internet and mobile phone coverage
▪ Internet and/or mobile cellular usage	5% of internet users 56% of mobile cellular users	35% of the population has an internet subscription, however only 4% has high speed internet 143% of the population has a mobile cellular subscription (many households have more than one subscription and/or sim card at a time)	▪ Internet and mobile cellular usage is high among the population with 77.9% of internet users and 93% of mobile cellular subscriptions

INDICATOR 16: Technology and Knowledge			
Measures	**Bangladesh**	**Vietnam**	**United States**
▪ Participation in knowledge and/or transfer projects (private sector)	▪ Capacity building in climate modeling workshop in partnership with the United Kingdom Met Office workshop) ▪ Early warning systems for agriculture in partnership with United States company Riverside Technology and two (2) Bangladeshi institutions (i.e. the Center for Environmental and Geographic Information Services, and the Bangladesh Disaster Preparedness Centre) ▪ Floating agriculture promoted through national projects (i.e. Reducing Vulnerability to Climate Change and the Sustainable Environment Management Programme)	Risk and adaptation assessment for the catfish farming industry[359] Knowledge transfer and capacity building on crab hatching technologies and best practices for sustaining and expanding crab aquaculture as a source of livelihood resilient to sea level rise; out of this project, two research centres were put in place, a few pilot projects received government funding to achieve commercial scale, and a number of hatcheries started using climate-resilient technology and farming practices[360] Engagement and consultation on climate change risk and adaptation perceptions in the shrimp farming industry[361]	Eighteen (18) out of over sixty (60) climate models used in the Coupled Model Intercomparison Project Phase 5 for the upcoming Sixth IPCC Assessment Report come from the United States[362] A number of demonstration projects are underway in the private sector as shown through the examples against Indicator 3 The United States is a major contributor to climate change adaptation funds promoting technology/knowledge transfer and capacity building for developing countries: ▪ It pledged US$290 million to the Climate Investment Fund Pilot Program for Climate Resilience[363] ▪ Climate change resilience is one of USAID's three (3) funding strategic objectives for 2012–2016[364]
▪ Participation in knowledge and/or transfer project (public sector)		USAID has supported technical training in Vietnam on climate variability and predictions[365] Thanks to UNDP funding and assistance from the United Kingdom Met Office, MOHC has developed its internal capability to model tropical cyclones trajectories and intensity using PRECIS Regional Climate Model simulations[366] Capacity-building on climate change risk and resilience in transportation for Provincial People's Committee staff[367] Capacity-building in the Binh Dinh province on mainstreaming climate change adaptation into local development plans, including support to the Climate Change Coordination Office in the preparation of a legal document to mainstream adaptation into local development plans[368]	
▪ Prevalence of technologies with climate change adaptation benefits			
▪ Integration of climate change impact and adaptation considerations in school and professional training curriculums		Alongside IMHEN, the Asian Disaster Preparedness Center is developing integrated training on climate change adaptation, disaster risk reduction and coastal zone management for government officials[369] Climate change education programs have been rolled out in schools in at least five (5) provinces[370] The Asian Cities Climate Change Resilience Network (ACCRN) is developing guidelines for integrating urban climate change resilience education into school curriculums in the Cam Le district[371]	

Appendix
Private sector consultation on drivers and barriers to climate change adaptation

A large number of factors can potentially influence private sector adaptation decisions. This work led to the compilation of the universe of data/information products, institutional arrangements, policies, economic incentives, and knowledge and technology resources that play a role in motivating the private sector in taking (or not taking) climate change adaptation actions. Depending on the context in which they occur, these factors will have varying degrees of influence on private sector adaptation – i.e. geographic locations of private sector operations, suppliers and customers, nature of economic activities and type of private sector organization concerned (e.g. subsistence workers, cooperatives, SMEs, large companies, multinationals and industry associations).

To inform the development of meaningful indicators and measures for the Index Framework, it was important to narrow down on the set of priority drivers and barriers for private sector adaptation drawing from the existing literature and the team's expert judgement. Six company representatives were approached for feedback on their views on the most important what drivers and barriers out of the universe of factors influencing private sector adaptation play a critical role. In selecting these companies, careful consideration was given to their locations, sectors of activity, global footprint of operations, levels of supply chain and/or community engagement, and their awareness of climate change adaptation. As a result, responses may be considered indicative of private sector views on enabling environments for adaptation, but not conclusive due to the small size of the sample.

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