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Climate Adaptation:
Seizing the Challenge

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The views expressed in this publication are those of selected members of the Global Agenda Council on Climate Change and do not necessarily reflect the views of all the members of the Council or of the World Economic Forum.

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Summary of Key Findings

1. Reductions in emissions of greenhouse gases are not happening fast enough. Preparing societies for the impacts of climate change, i.e. adaptation, must therefore happen in tandem with mitigation efforts.
2. Indices can inform decision makers on where climate adaptation is most necessary, and how best to allocate adaptation investments, including for prioritizing pre-disaster efforts. African nations, particularly Sub-Saharan, consistently emerge as the most vulnerable to climate change and the least ready to adapt, while a clear difference appears between developed and developing nations. More and better national data, particularly in developing countries, is required, while obtaining local data for comparison, for example across cities, may be a challenge. Metrics that are used to assess adaptation need can have conflicting aims and conclusions but competing methodologies can shed new light on seemingly intractable problems.
3. Up to 65% of the increase in the projected losses due to climate change could be averted cost effectively through adaptation investment. Decision makers need to look at "total climate risk" when considering adaptation investment and finance – this takes into account existing risk, future risk due to development and additional risk due to climate change.
4. Private sector funding will be needed to finance investments – the cash-strapped public sector will not be able to provide it all. Public sector funding can be leveraged effectively however and the public sector can also provide a framework that makes this investment attractive.
5. Water, food and energy systems are inextricably linked and so the use and management and particularly shortages of one can affect another, e.g. water shortages can affect crop yields, power generation and industrial processes. It is therefore crucial to consider each part of the water-food-energy nexus when making an investment or policy decision so that another part of the nexus is not compromised. Meanwhile climate change is stressing the nexus. Addressing this is beyond the scope of individual governments, companies or NGOs acting alone. Since awareness of the nexus is low, the current behaviour of companies or governments may not take it into account and therefore stress it further. A new approach is therefore required that involves multiple stakeholders with the aim of addressing these issues in a co-ordinated and holistic manner.

Introduction

By Wu Changhua, Director, Greater China, The Climate Group
and Chair of the Global Agenda Council on Climate Change

Scientific and business communities increasingly recognize that climate change is causing weather extremes and precipitating natural disasters, such as the European heat wave of 2003, the drought in East Africa in 2011, and in 2012 the worst drought in the US since 1956. In one report, which examined a number of countries, losses are projected at 1-12% of GDP per annum based on current climate patterns.[1] Based on the projection of future economic development and analysis of various climate scenarios, these losses, in some cases, are likely to rise to up to 19% of GDP by 2030. Depending on the region, up to 69% of this increase will be driven by economic development in hazard-prone areas, such as cities in coastal regions.[2]

Human intervention to reduce emission of greenhouse gases and so reduce the damage through climate mitigation is one way to address this. But international agreements and action on mitigation have not appreciably slowed or reversed global emissions to date. Thus, the policy, business and academic communities are beginning to pay increased attention to the need for climate adaptation, defined as adjusting to the effects of climate change. This includes changes in processes, practices and structures to moderate potential damage e.g. power plants investing in different cooling systems or building sea walls. According to the World Bank, up to US$ 100 billion annually in climate adaptation financing will be needed throughout the next 40 years in developing countries alone.[3]

Making progress on this issue requires assessment of where the problem is greatest, what the costs will be, how to target investment cost effectively, and how to finance it. However, current adaptation funding is relatively miniscule. Multilateral development institutions are expanding their resource commitments, but have failed, so far, to provide all the funding required. It will be difficult for cash-strapped governments to fill this void on their own. The private sector will have to step in, and this provides it with an opportunity to not only mitigate global risk in its value chain due to climate change but also to strengthen resilience in developing countries.

This publication is an attempt by selected experts from the Global Agenda Council on Climate Change to capture some of the latest thinking in the field of climate adaptation and financing, with the goal of assisting decision makers in both public and private sectors to gain a better understanding of this issue. The first chapter examines existing metrics that identify which countries and/or regions are most vulnerable to and least prepared for the effects of climate change. The second chapter then looks at how to assess the costs of climate change and what measures can be employed to avert them in a cost-effective manner. The third chapter looks at how to finance those measures, in particular how to use public finance to leverage private finance to fill the funding gap. Underpinning all these chapters is the crucial importance of looking at investments in a holistic way across the water-food-energy nexus, which is explored in the fourth chapter.

Each chapter contains case studies that illustrate specific solutions and also suggests areas for further research. While this is an initial assessment, and certainly not the last word on this important topic, the overall aim of the publication is to stress that proper metrics and correct government incentives, underpinned by a solid understanding of the nexus between energy, water and food, can enable decision-makers to save lives and improve livelihoods in the face of growing climate change.

Chapter 1: Sizing the Resilience Challenge

By Juan José Daboub, Founding Chief Executive Officer,
Global Adaptation Institute (now Notre Dame Global Adaptation Index)
and Vice-Chair of the Global Agenda Council on Climate Change

Metrics to assess vulnerability to climate change and its impacts are a prerequisite to any action on adaptation. Society needs ways to assess total climate risk, defined as the sum of 1) today's risk, 2) additional risk due to major global trends like urbanization, population shifts and economic development and 3) further aggravation due to climate change. By the same token, readiness to adapt or the capacity of people to innovate and create solutions should be part of the equation. Metrics can help decision makers identify and prioritize adaptation measures to allocate investment most effectively, and in this way build resilience to climate change.

In this chapter we look at the metrics that are available, specifically adaptation indices, review their approaches and results, and identify gaps where improvements could be made.

Measuring climate resilience

Indices are created for a variety of reasons and audiences. Current adaptation indices typically draw upon environmental and development indices. Environmental indices tend to measure biophysical conditions, pollutants and biodiversity while many development indices focus on governance, economic and "basic needs" indicators. Several indicators and indices are beginning to bridge these two disciplines. Particularly in regard to climate adaptation, indices are beginning to focus both on traditional environmental indicators (such as water quality) and development indicators (such as rule of law and education levels). For societies to adapt, it is essential that institutions understand the link between the physical assets crucial to human well-being and development (primarily water, energy, agricultural and infrastructure systems), and the conditions in place to improve the resilience of these systems (governance and social indicators).

Below is an overview of several leading country-based indices that focus on assessing climate resilience and/or vulnerability. Note that this is not a comprehensive study.

Climate Change Vulnerability Index (CCVI) and Risk Atlas: Maplecroft, a global risk analytics firm, produces an annual vulnerability index that forms a central pillar of its Climate Change and Environmental Risk Atlas.[4]

According to Maplecroft, the Climate Change Vulnerability Index (CCVI) "assesses 193 countries and highlights subnational hotspots of risk. The index is composed of the exposure of countries to climate-related natural hazards and the sensitivity of populations in terms of concentration, development, agricultural dependency and conflict. This is then considered in the context of the ability of a country's government and institutions to adapt, or take advantage of the potential effects of climate change".[5]

The Maplecroft Risk Atlas prioritizes risk analysis for a primarily private-sector audience, with targeted corporate-focused services accompanying the atlas. A notable feature is that it explicitly communicates vulnerability down to a scale of 22 sq km.[6]

Climate Change Vulnerability Index (CCVI): The Center for Global Development (CGD), an independent US-based non-profit think tank, has created an index that measures the vulnerability of 233 countries to weather-related disasters, sea level rise and reduced agricultural productivity.[7] This index is targeted at donors and the international aid community. It ranks Somalia, Burundi, Myanmar, Central African Republic and Eritrea as the five countries in most need of aid. The accompanying paper to the dataset develops resource allocation formulas for three scenarios — "(1) potential climate impacts alone, as measured by the three indicators; (2) case 1 adjusted for differential country vulnerability, which is affected by economic development and governance; and (3) case 2 adjusted for donor concerns related to project economics: inter-country differences in project unit costs and probabilities of project success".[8]

Climate Vulnerability Monitor (CVM): Created by Development Assistance Research Associates (DARA), an independent, non-profit organization based in Spain, this index examines the vulnerability of 184 countries across four areas of impact (environmental disasters, habitat change, health impact and industry stress) using "34 climate and carbon-related indicators".[9] While it does not rank countries, it classifies them according to five levels of vulnerability from acute to low. It measures present vulnerability and makes assessments of vulnerability until 2030.

The CVM not only communicates climate impacts but also links these to the need for further action to mitigate climate change. In this regard, this index is unique in linking the policy implications of climate mitigation to climate impacts.

Global Climate Risk Index: The Global Climate Risk Index, produced by Germanwatch, a non-profit, non-governmental organisation that works to promote "global equity and the preservation of livelihoods"[10], analyses to what extent countries have been affected by the impacts of weather-related loss events (storms, floods, heat waves and other events). It considers both human and economic losses.

Germanwatch takes a more open-ended approach than the other organisations, providing data on several weather-related climate risks with the goal of highlighting these risks to a broad audience.

The Notre Dame Global Adaptation Index (ND-GAIN): ND-GAIN is an open source index available online that ranks 192 countries based on their vulnerability to climate change and readiness to adapt.[11] The underlying data are presented in country profiles. The index aims to help businesses and the public sector better prioritize adaptation investments for a more efficient response to the immediate global challenges ahead. The index provides a matrix that plots a country's vulnerability (in terms of water, food, health, infrastructure, ecosystem services and human habitat) and its readiness to adapt.

The ND-GAIN index helps to determine which countries are most in need of international donor assistance and which are most primed for investment to increase resilience. It helps decision-makers focus on specific variables that have the biggest impact on country vulnerability (see also more detailed case study below).

Other indices: There are other indices that do not specifically focus on climate change adaptation but include indicators that can help measure vulnerability, adaptive capacity and governance issues. These include:

- Environmental Vulnerability Index, published by Sopac[12]
- Environmental Performance Index, Yale University[13]
- Global Competitiveness Report, World Economic Forum[14]
- The State of Food Insecurity in the World, FAO[15]
- Various water poverty indices e.g. ASCE Library water poverty index[16]
- Water Scarcity Index, Grida[17]
- World Governance Indicators, World Bank[18]

Selected Findings from the Indices

Some indices are useful in identifying where need is most urgent, such as in the wake of disasters or where humanitarian aid is needed in highly vulnerable countries. Other indices can help prioritize pre-disaster efforts such as prevention, preparedness and risk transfer.

Looking at a specific region, such as sub-Saharan Africa, further illustrates the utility of and distinctions between these various indices. As an example, while intra-continental variation exists, African nations, particularly sub-Saharan nations, consistently rank as the most vulnerable to climate impacts and least prepared to address vulnerabilities. Of the 20 most at risk countries in the ND-GAIN index, for example, 16 are located in Sub-Saharan Africa. The CVM also lists the majority of this region as "acute" in terms of climate vulnerability.

By contrast, the Global Climate Risk Index does not see high levels of risk for Africa, rather highlighting risks in South Asia and Latin America. This discrepancy highlights the difference in focus of many indices. Indices, such as the Global Climate Risk Index, that focus primarily on impacts (exposure to weather and climatic events) and not ability to adjust/build resilience against these impacts, will show different vulnerabilities than indices that include metrics on adaptive capacity and socioeconomic indicators.

While the lists of the most vulnerable and most resilient countries are far from uniform across the surveyed indices, there is a clear difference between developed and developing countries. Throughout these indices, the majority of Western, industrialized nations are the least vulnerable and most ready to adapt. Still, several developing countries, such as Chile and Uruguay, show better than expected performance than one would expect given their level of GDP.

Future Metric Improvements

Work is required in several areas to improve the current state of adaptation metrics. However, it will probably be several years before a significant portion of their target audience, including governments or private sector actors, initiate changes or enact policy positions in response to rankings or metrics. There is therefore an opportunity to continue to refine existing indices to ensure they are meeting the decision-making needs of target stakeholders while continuing to raise awareness about climate adaptation. Some key areas where more attention and work are likely to be required are the following:

- **Compilation of local data:** As can be seen, the indices outlined above measure vulnerability and readiness mostly at a national level. However, measuring vulnerability and readiness at the local level is essential. For example, there are clear variations within large nations, such as China, Brazil and the United States, in agricultural productivity, water security and energy access. Moreover, even economic and governance conditions can vary significantly enough to warrant more fine-grained, intra-country, analysis.
- **Challenge of comparability:** As more local data are compiled, comparability of adaptation metrics may however pose a challenge. Specific data may not be as accurate in some areas or may not be collected at all at state or urban levels. Thus, rankings of cities (e.g. New Delhi relative to Tokyo), or states from different countries, may entail the use of different metrics or proxies. International urban rankings of all sorts however do exist, demonstrating that this is not an insurmountable challenge.

  Furthermore, some countries may have specific and well-collected data relative to other nations. Metric leaders will need to determine whether or not to forgo detailed data that can more accurately portray adaptation within a country in order to be comparable to countries with less data. Several endeavours to granularize adaptation metrics provide lessons for future effort. For instance, *cal-adapt.org* provides granular information on a limited set of vulnerability variables (temperature, snowpack, sea-level rise, wildfire and precipitation projections).
- **Need for local guidance:** When comparable data becomes hard to collect at a local level, metrics leaders may find that providing guidance and methodologies to individuals and communities takes precedence over relative vulnerability data collection and interpretation. For instance, encouraging local organizations to seek out information or consider the metrics used in national or state indicators could be useful.

  One nascent effort to determine the type of metrics needed for small- and medium-sized enterprises in Mexico shows the benefit of working with local decision-makers to draft guidelines. The SME Resilience Guidelines project[19] collected data from businesses in each state in Mexico using vulnerability and readiness components. The project takes users through a step-by-step process to assess business risks, community vulnerability and readiness to take action. Based on the ND-GAIN Index, it collects data on vulnerability measures such as energy, water, food, infrastructure and health as well as readiness measures such as governance and economic data.
- **Balancing data requirements:** Indices contain a varied number of countries depending on the number of indicators selected. Those that use only a few indicators can likely cover a larger number of countries than those that include 30 or 40 indicators. There is a balancing act between including as many countries as possible and including enough indicators to represent a holistic picture of a country's resilience. Notably, countries that often do not participate in international conventions or cooperate in information sharing, such as North Korea and Cuba, may create persistent difficulties in data collection. Other very poor countries do not have the resources to collect nation-wide data.
- **Conflicting messages from different metrics:** Lessons from metrics in other sectors show that while multiple indices can provide alternative viewpoints for decision-makers, multiple indices can also lead to confusion on how best to move forward. However, they can also illuminate new solutions: for sectors such as education, economics and governance, competing methodologies with fresh perspectives can shed new light on seemingly intractable problems.

Conclusion

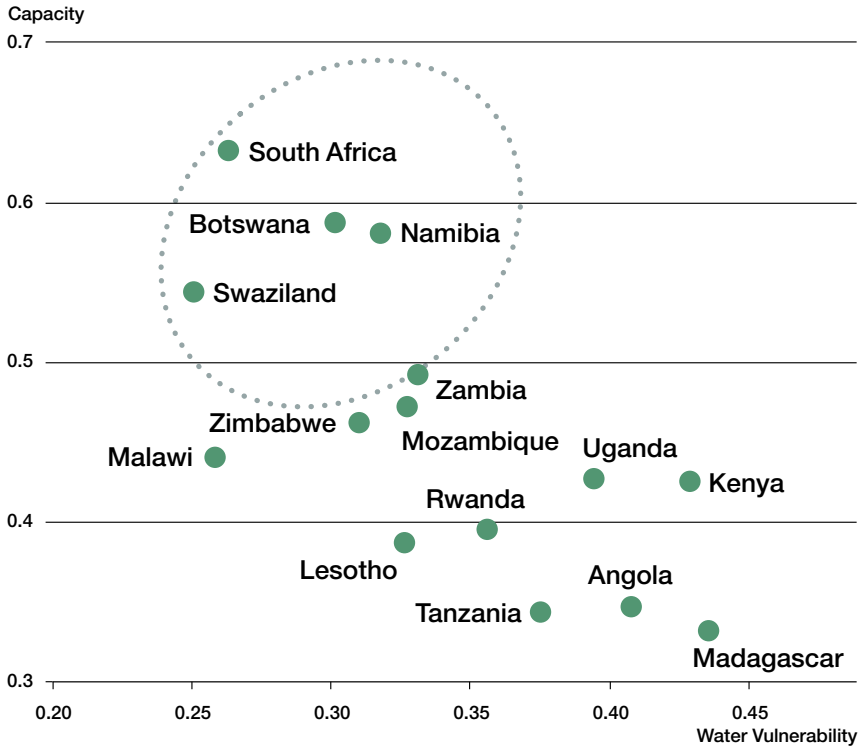
The metrics reviewed above show that the developing countries are the most vulnerable and least ready to adapt to climate change. Further work is required to improve indices and there is a window of opportunity to do so while awareness of the need for climate adaptation builds. There may be differing levels of local data between countries making comparison difficult, for instance across cities. Indices may have differing aims and conclusions, which may at times lead to confusion, but may also highlight opportunities. More and better national and sub-national data are also required.

Case Study: ND-GAIN in practice

The ND-GAIN index scores 192 countries' vulnerability to climate change and readiness to adapt with the explicit aim of furthering investment in adaptation. For example, a company seeking to expand in southern Africa that prioritizes sound water management could use metrics in the index to minimize risk and determine opportunities. That company could compare countries' water vulnerability and the capacity to adapt/cope with climate risks (Figure 1) or examine individual vulnerability and readiness indicators that are key to business operations (Figure 2).

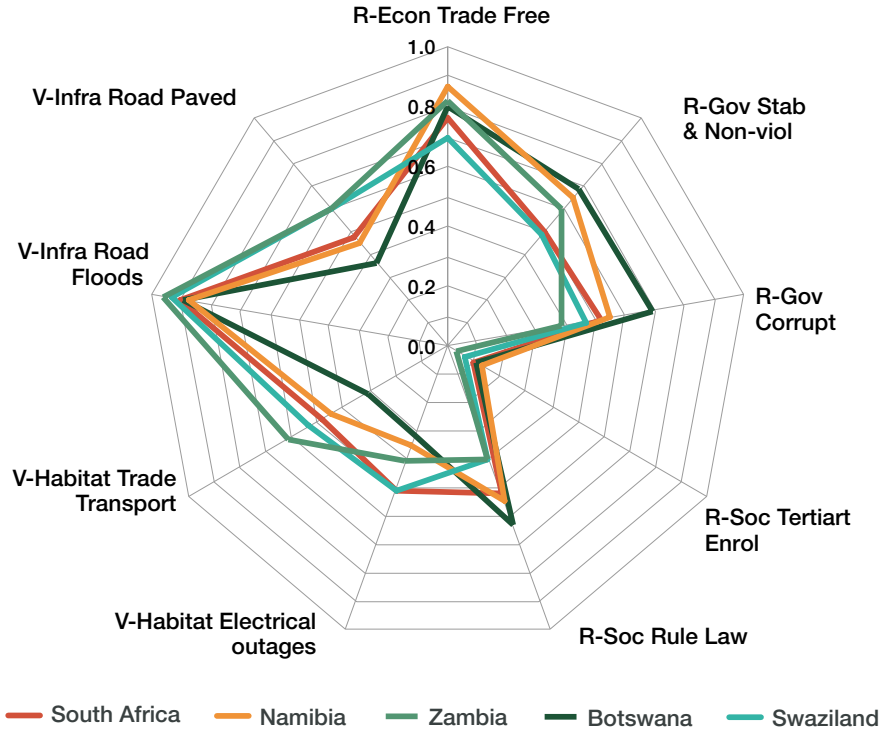
It can also be used by companies and NGOs working directly on improving community resilience to identify the areas most in need within a given country. The index measures each country in terms of its vulnerability and readiness and combines these into a score. For example, Botswana is ranked 82nd in the index, while Denmark is ranked 1st. Botswana is highly vulnerable but highly ready to adapt, while Denmark has low vulnerability and is highly ready. Of the 50 indicators that make up its ND-GAIN ranking, Botswana performs the worst in terms of health workers per capita, with 0.89 workers per 1,000 people for a score of 0.859 (the higher the score, the worse the performance) while Denmark has 10.95 workers per 1,000 people, and scores 0.082.

Figure 1: Comparing Water Capacity in Southern Africa



Source: ND-GAIN. Circle indicates those countries that are least vulnerable and most ready to adapt.

Figure 2: Indicators key to businesses



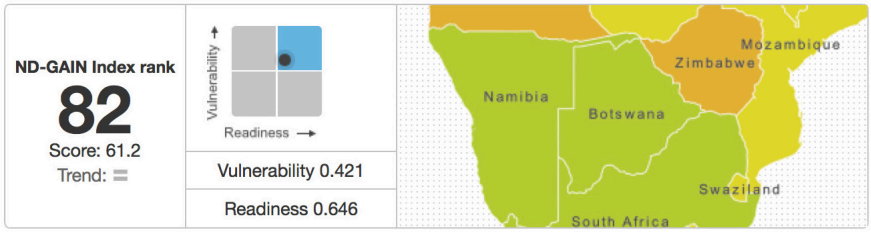
Source: ND-GAIN

Figure 3: Comparing Botswana and Denmark using ND-GAIN

Botswana

GDP (PPP) per capita (2012): 11,794.82 USD

Population (2012): 1,981,576



The high vulnerability score and high readiness score of Botswana places it in the upper-right quadrant of the Readiness Matrix. It is on the road to responding effectively to climate change, but the adaptation needs and urgency to act are greater. Botswana is the 60th most vulnerable country and the 50th most ready country.

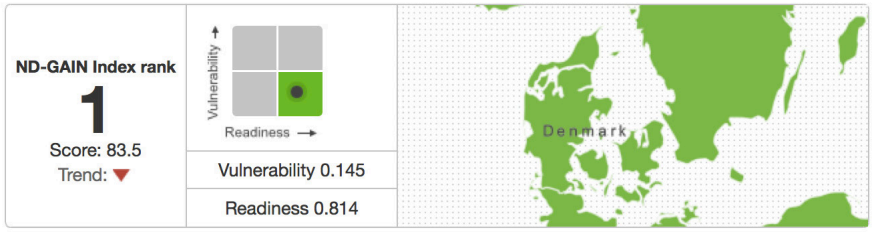
ND-GAIN Ranking since 1995

Year	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Ranking	94	92	80	84	83	83	82	85	74	75	79	85	87	85	84	86	85	82

Denmark

GDP (PPP) per capita (2012): 31,960.90 USD

Population (2012): 5,523,095



The low vulnerability score and high readiness score of Denmark places it in the lower-right quadrant of the Readiness Matrix. Adaptation challenges still exist, but Denmark is well positioned to adapt. Denmark is the 2nd least vulnerable country and the 5th most ready country.

ND-GAIN Ranking since 1995

Year	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Ranking	3	2	3	3	2	2	2	1	1	1	1	1	1	1	1	1	1	1

Source: ND-GAIN

Chapter 2: Economics of Climate Adaptation

By David Bresch, Global Head Sustainability, Swiss Re

This chapter examines how decision makers can assess potential losses due to climate change and which measures will be most cost effective in averting those losses, with a focus on one particular methodology developed by the Economics of Climate Adaptation (ECA).[20] The good news is that the ECA methodology identifies that cost-effective adaptation measures have significant potential. In general, between 40% and 65% of the projected increases in losses can be averted cost-effectively – a strong case for preventive action.[21]

Asking the right questions

The key questions decision makers ask are:

1. What is the potential climate-related damage to our economies and societies over the coming decades?
2. How much of that damage can we avert, and with what measures?
3. What investment will be required to fund those measures, and will the benefits of that investment outweigh the costs?

The ECA methodology is an attempt to help decision makers answer these questions. Developed by the Economics of Climate Adaptation Working Group, a partnership of key public and private sector organisations, it provides decision makers with a fact base to answer these questions in a systematic way. The methodology serves as a kind of reference, having been applied in 20 case studies across the globe from Maharashtra in India to Florida in the US, covering different types of hazards, regions and economic sectors. It enables decision makers to understand the impact of climate change on their economies and identify specific actions to minimize that impact at the lowest cost to society. It therefore enables decision makers to integrate adaptation with economic development and sustainable growth.

Aims and principles of the ECA

The methodology has sought to address the following requirements:

1. *Provide holistic analyses linking climate hazards to adaptation measures:* This entailed bringing together a sequence of analyses to quantify the risk from climate hazards based on climate change scenarios, assessing the costs and benefits of adaptation measures, and considering qualitatively the non-economic benefits of such measures.
2. *Perform a consistent comparison of adaptation measures:* By applying a comparable methodology applicable to all hazards and across all sectors, decision-makers are informed about adaptation trade-offs between economic sectors.
3. *Be applicable to both the developed and the developing world:* Portions of the analyses required already exist in the developed world, while in the developing world key data sets need to be created, for example, physical hazard models connected to IPCC projections, asset and income census data, and vulnerability of infrastructure.
4. *Serve stakeholder needs:* This is done by weaving these components into a clear and relevant tool for decision-makers in their own countries, regions and cities.

In line with these objectives, the methodology follows a set of guiding principles which are linked to the tangible outputs of the analyses:

- *Assess "total climate risk"*: This consists of current and future risk from climate hazards – that is, not only the expected additional risk from climate change but also risks due to current climate risks – and developed loss models with multiple climate change scenarios to reflect uncertainty. Decision makers must respond to the total risk facing society and not only to the incremental risk;
- *Be transparent*: Prepare to share the underlying steps, assumptions and tools with local decision-makers and a global audience of stakeholders;
- *Build modular tools*: Ensure that the methodology – the models for both risk assessment and cost-benefit evaluation of adaptation measures – allows for modification and refinement based on future findings from researchers[22] (for example, new insights into how climate change affects local hazard patterns);
- *Apply the analysis across sectors*: Quantify economic loss from the "bottom-up" by including detailed risk assessments of physical assets and incomes across different sectors of the economy.

The Methodology in detail

The ECA methodology consists of the following steps:

1) Quantifying expected losses and the costs of adaptation

Expected losses and costs of adaptation are two complementary ways of examining the impact of climate change. Expected loss is the amount of damage likely to occur in a defined time period (for example, one year). It is calculated as a function of the severity and frequency of the climate hazard, the value of assets (for example, buildings) exposed to the hazard, and the vulnerability of those assets to the hazard. A portion – sometimes nearly all – of the expected loss can be addressed by adaptation measures.

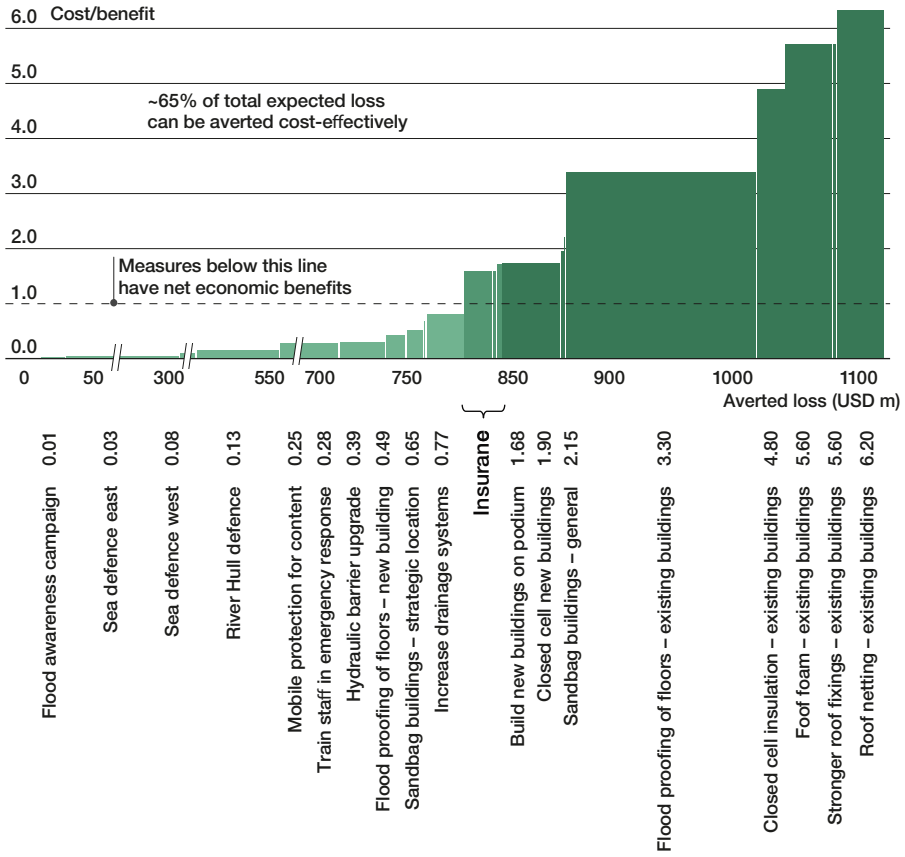
For example, the ECA study looked at an urban area in a developed country, the city of Hull in the UK, and the state of Maharashtra in India, which included rural settings within a developing country. In Hull, the study found that 65% of the loss under a high climate change scenario could be cost effectively averted using climate adaptation measures (see chart below).

In Maharashtra, almost 50% of the loss under a high climate change scenario could be averted.

The cost of adaptation is the investment required in adaptation measures aimed at minimizing the damage from future climate hazards. Hence, the total cost of climate change is the sum of the cost of adaptation and any residual expected losses not averted by the adaptation measures. The focus on expected losses and adaptation measures at the local level is guided by the practical assumption that climate change will have significant local impacts requiring the urgent focus of local decision-makers. Despite uncertainties and the overlapping effects of climate change in the economic, environmental and social sectors, these steps and calculations are executable even in settings where data is often sparse.

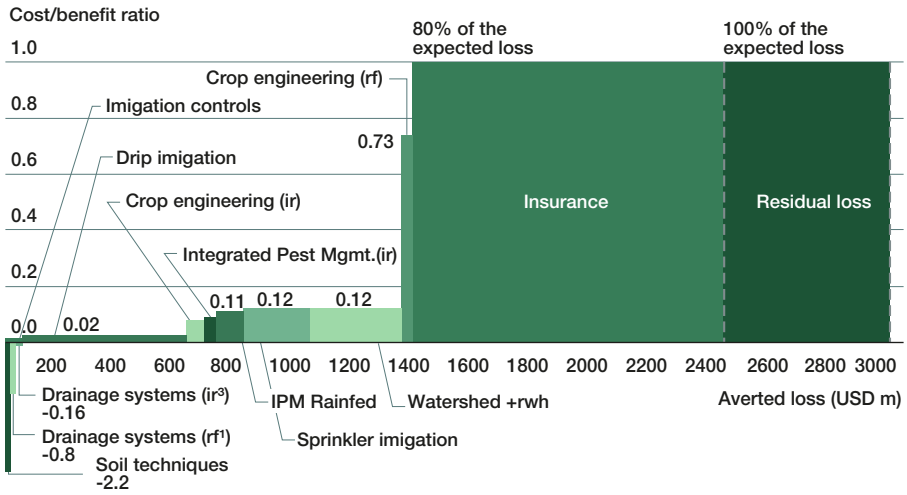
Example city of Hull, UK

The adaptation cost curve for the city of Hull, UK (see source for details). For each adaptation measure (rectangle), the loss aversion potential (horizontal axis) and its cost /benefit ratio (vertical axis) is shown. Note that for this case, 65% of the loss under a high climate change scenario can be cost- effectively averted by prevention and inter- vention measures. Insurance covers another ~15% of the expected loss. Further measures (to the right, such as elevating existing buildings to prevent flooding) are not cost- effective.



Example Maharashtra, India:

The adaptation cost curve for drought risk in the state of Maharashtra, India (see source for details). For each adaptation measure (rectangle), the loss aversion potential (horizontal axis) and its cost/benefit ratio (vertical axis) is shown. Note that for this case, almost 50% of the loss under a high climate change scenario can be cost-effectively averted by prevention and intervention measures. Index insurance covers another ~30% of the expected loss.



Source: Report of the Economics of Climate Adaptation Working Group 2009

2) Consistent application

Replicable analytical approaches will ensure consistency, but require streamlining assumptions including:

- Scenario planning to address uncertainty
- Assumptions used to forecast economic and population growth
- Adaptation measures assessed using a cost-benefit analysis

a) Scenario planning to address uncertainty

Future climate uncertainty needs to be addressed by developing discrete scenarios based on publicly available scientific research. Note that integrated advanced approaches such as decision trees or chaos theory could be applied to more accurately assess the full range of uncertainties. However, in light of the pressing need for rapid decisions and actions in adapting to climate change, these sophisticated models are subject to the law of diminishing returns – they may provide only a slightly more precise answer for significantly more effort invested. In addition, these complex models risk decreasing the replicability of analyses and, more importantly, may become less transparent and traceable to decision-makers who are not climate experts.

b) Assumptions used to forecast economic and population growth

Simple assumptions on economic and population growth should be used to increase transparency of the model instead of leveraging general equilibrium methodology concepts. General equilibrium models incorporate the impact of economic investments – including adaptation measures – on future GDP and population growth. These models try to estimate the feedback loop dynamically in a system. However, while the adaptation measures are likely to feed back into future growth, the ECA chose to make economic and population growth independent of investment choices. The advantage of using such simplifying assumptions is that practical and understandable models are more likely to gain acceptance among non-experts.

c) Adaptation measures assessed using a cost-benefit analysis

A societal cost-benefit analysis methodology is used to assess measures. Cost-benefit ratios may not be perfect indicators of the value of adaptation measures: for example, the inclusion of various costs and benefits in net present value cash flow calculations are subject to debate. Nonetheless, cost-benefit approaches are commonly used in national, regional and local decision-making, and are a recognized form of presenting information to support trade-off decisions.

The end product of this analysis is a cost-benefit curve comparing the selected adaptation measures rather than a recommendation to implement specific measures. It should be emphasized that this methodology is designed to support local decision-making processes rather than to provide a prescriptive answer on which adaptation measures a location should implement. A cost-benefit analysis is only one of several decision-making criteria, including the flexibility of measures, capital expenditure constraints, cultural preferences, and the value placed on ecosystems. The local expertise of decision-makers is therefore critical in evaluating which measures are most attractive when taking these factors into account.

In the next chapter we look at how climate adaptation investment can be financed.

Chapter 3: Financing Adaptation

By Richard Saines, Head, North America Climate Change and Environmental Markets, Baker & McKenzie LLP

This chapter examines what type of enabling environment would attract and optimize public and private sector finance for climate adaptation efforts and how to use public funds to leverage private investment. It does not seek to justify why adaptation is required nor why the private sector needs to be involved in adaptation finance.

The Importance of the Private Sector and its Relationship with the Public Sector

To date, most adaptation efforts have been funded from public sources or sources that do not seek significant monetary returns on investment. However, those sources are limited and insufficient in both developing and developed countries to support the number of adaptation projects likely to be required to avoid catastrophic risk of loss in many areas. Research findings suggest that a solution to the current deficit of funding for adaptation projects is increased levels of investment from the private sector.

This will necessitate the creation of a return on investment for those private investors. However, adaptation projects typically do not generate returns that can be easily passed on to private investors. For example, a sea wall may provide significant benefits to homeowners and businesses by virtue of the protection it offers. It is difficult though to quantify such benefits and private investors may be unable to secure sufficient revenues from the homeowners and businesses that benefit to provide the returns necessary.

A solution to the sea-wall scenario may be for the government to intercede and collect funds from the homeowners and businesses that benefit through taxes or other measures that may be passed onto the private investor. But the government's role in this scenario must be balanced: a heavy-handed approach risks jeopardizing an efficient allocation of resources, and a lean approach will not attract the type of investment that is required to build the sea wall in the first place.

Further, private sector involvement also requires some level of public sector input, typically to frame the rules of investment, or to allocate limited public funds in an efficient manner to "de-risk" the investment and attract or "leverage" private capital.

The suggested solution to the adaptation financing deficit is for the private sector to work synergistically with the public sector to create projects that generate a return on investment. This investment and collaboration can enhance climate resilience of vulnerable populations and infrastructure.

Adaptation Finance Literature Review

This chapter is informed by a review of the available literature on the topic of adaptation finance (as listed in Appendix B). While the review remains an on-going process, certain patterns and key issues that are likely to influence the development of climate adaptation investment mechanisms involving the private sector have clearly emerged:

- Climate adaptation finance deficits exist both in developed and developing countries. In some countries (such as China, for example), adaptation projects may theoretically be perceived as equally important as mitigation efforts. But such dual-focus is not yet reflected in the real-world deployment of climate finance.
- There is overlap between mitigation and adaptation efforts, and finding ways to scale both with strategic investments is a win-win opportunity for investment and risk mitigation. For such investments, the co-benefits of mitigation and adaptation should be recorded and reflected in the investment decision.
- It is difficult to distinguish and measure the effectiveness of traditional development finance versus adaptation finance. However, doing so is necessary to define (and ultimately monetize) the value of the incremental costs associated with building enhanced climate resilience. Tracking and measuring the costs and efficacy of investments in enhancing resilience (as distinct from traditional development assistance) is essential to create a "return on investment" profile.
- There is no universally-agreed method of measuring the effectiveness of adaptation efforts. Although mitigation targets exist, there are few, if any, adaptation "policy targets". The metrics discussed in chapter 1 offer insights into how countries could compare their relative vulnerability and readiness, which is an important component of adaptation measurement.
- Although there is policy discussion regarding the role of the private sector, business analysis remains in its infancy (with the exception of perhaps insurance). The insurance sector approach to defining risk and value can inform the analysis of other sectors. However, it should be noted that insurance coverage is inadequate in some countries, where they mostly rely on public subsidies and there is very low participation by commercial financial institutions (see Appendix C for a specific insurance case study).
- To date, most adaptation efforts have been funded from public sources or sources that do not seek significant monetary returns on investment. A step-change in approach is required. A top-down driven input to adaptation, through mostly public financing, is inadequate and typically consists of disaster relief rather than pro-active investment in resilience.
- Many developing countries lack the institutional capacity to carry out the adaptation measures that are needed. There is a concentration of private finance in some countries but not others.
- Most case studies identified in the literature do not provide examples from which to build a private sector investment vehicle, as they are either (1) small scale pilots that were funded by government grants or specialized multilateral financing mechanisms, i.e. not from the private sector; or (2) in the case of examples from the insurance sector (i.e. the Swiss Re case studies), the emphasis has been placed on mobilizing public sector finances to avert the risk of future losses instead of creating a present day return on investment for private investors. Such projects are worthwhile but they do not offer designs that can be used to pilot scalable private projects. Furthermore, most infrastructure projects to date have not ascribed a value (or cost) to their impact on climate resilience, as there is no recognized revenue stream associated with enhanced resilience.[23]

Essential Criteria for Adaptation Financing Mechanisms

	Criterion	Description
1	Developed in an environment that is sufficiently certain	Policy direction, tools and instruments (i.e. the architecture supporting adaptation projects) need to be sufficiently certain, both in scope and time, to enable the private sector to invest with confidence.
2	Generate ROI	The private sector will not invest unless there is an attractive risk-adjusted return on investment. Identifying a way to reduce risk sufficiently, to enable a predictable, low risk, single digit return over the long term, is one of the most important elements of creating a viable investment vehicle for the right type of private sector investment.
3	Measurable	A critical component of any financial vehicle will be to define and develop reliable metrics that speak directly to private sector concerns at the investment level.
4	Politically attainable	In theory, the best private finance mechanism would not require any governmental action. In reality, addressing the climate adaptation challenge will require a coordinated, aligned and productive relationship between the private sector and governments.
5	Environmentally sound	Privately financed climate adaptation funding will be counter-productive if it unacceptably exacerbates climate change.

Desirable Criteria for Adaptation Financing Mechanisms

	Criterion	Description
1	Activities to be carried out in developing and least developed countries	Reaching those populations that are most vulnerable to climate change and least equipped to respond to such change is a critical objective, but is a challenge for private sector finance-based investing in the short term.
2	Mechanism to be as open and simple as possible	While simplicity is important for general awareness, "buy-in", transparency and accountability, this challenge is inherently complex and may require complex solutions.

Investment Criteria for a Private Sector Adaptation Finance Mechanism

To obtain private sector investment, any adaptation finance mechanism or vehicle will likely need to satisfy the above essential and desirable criteria:

Regional or Sectoral Variations

The above criteria describe what a private sector adaptation finance mechanism will need in order to be replicable and scalable. Although they are used to assess the case studies identified below, there is an opportunity for further work to develop more detailed criteria for specific sectors and/or regions. Such additional work would map out the value chain of the nominated sector or region, which could then be used to understand in more detail what type of projects would be needed with what type of financing to achieve enhanced resilience.

Case Studies of Climate Smart Investments

Below we review case studies of climate smart investments, drawn from the following areas:

- Agriculture
- Water management
  - urban storm water flows
  - coastal and riparian zone flood risk and planning
    - building standards
    - zoning restrictions
    - natural infrastructure and land use
  - long-term water availability risks
- Energy

In this chapter we examine two case studies in detail, one from a developing and the other from a developed country setting:

- The Coffee Farmer Resilience Initiative, Central America
- Desalination in San Diego: The Poseidon Carlsbad Desalination Project

Further cases are examined in Appendix C. In each case, an assessment is offered of the degree to which the case studies satisfy the criteria identified above for attracting private sector finance. Our hypothesis is that not all areas will be suitable for private sector engagement, but to the extent some of the above areas can be served, that would help to optimize the focus of the limited public sector resources towards remaining areas that are most impactful.

Case Study 1: Coffee Farmer Resilience Initiative, Central America

Background

Coffee is a key crop in Central America but is susceptible to attack by a disease known as roya (coffee rust). The disease infects individual coffee leaves and has spread due to increased temperatures. According to the International Coffee Organization (ICO), the current epidemic in Central America is the highest incidence of roya seen in over 40 years with roya-related losses in 2012 estimated to be upwards of 2.7 million bags, totalling US$ 500 million in lost revenue, and 374,000 job losses in 2012-2013. Most small-scale cooperatives are simply not in a position to combat such a complicated crisis, either in terms of financing or adaptation.

The Coffee Farmer Resilience Initiative

Root Capital, a non-profit social investment fund, invests in agricultural businesses with an aim to secure long-term rural prosperity for small-scale farmers across Africa and Latin America. By providing credit, delivering financial training, and strengthening market linkages for these businesses, Root Capital hopes to improve rural livelihoods and promote environmentally sustainable agricultural practices. As of 31 March 2013, it had disbursed over US$ 500 million in loans serving agricultural businesses that generate long-term social, economic and environmental sustainability for small-scale farmers around the world, while maintaining a 100% repayment rate to its investors since its lending program began in 1999.

Responding to the Central American roya crisis, Root Capital is pioneering a "climate-smart" financial investment strategy for coffee renovation, which uses the roya crisis as the entry point for a more holistic engagement with producer organizations in developing and implementing a range of farmer- and enterprise-level investments.

The model for Root Capital's Coffee Farmer Resilience Initiative includes the following key components:

- Long-term financing of coffee renovation (replanting) and rehabilitation.
- Short-term lending for trade capital credit or capital expenditure.
- Financial training to cooperatives to build their capacity to manage internal credit systems for on-lending to farmer members for renovation investments.
- Climate-smart agronomic training coordination.
- Income diversification strategies.

A Model of Partnership

From 2011 through late 2013, Root Capital approved four loans totalling over US$ 800,000 to support a first round of coffee renovation activities. Capital for these loans was drawn from the following sources – philanthropic foundations (35%), government agencies (31%), private investors (17%), corporations (14%) and non-profit organizations and religious institutions (3%).

Root Capital's Coffee Farmer Resilience Initiative entails collaboration and, in some cases, shared risk among multiple actors across the coffee value chain. To that end, Root Capital is partnering with major coffee buyers, brokers, importers and other value chain actors on various components of its climate-smart adaptation finance model, including through:

Securing long-term purchase commitments with price floors and differentials based on quality and availability.

Launching the Resilience Fund where Root Capital is exploring opportunities for collaboration with private sector companies and philanthropic partners to launch a leveraged 1:1 matching investment fund that will channel private sector capital to support technical assistance around renovation, with the goal of stabilizing supply chains and building resilient livelihoods for coffee producers and their families.

Risk sharing facilities to support the underwriting of long-term loans. As of late 2013, Root Capital had approved one US$ 2 million loan for coffee renovation under the Coffee Farmer Resilience Initiative.

Below we provide a "Report Card" analyzing the Coffee Farmer Resilience Initiative against the identified set of essential and desirable criteria to determine the degree to which such initiative has the potential to attract private sector finance at scale. Each criterion is assessed on a scale from 1 to 5, with 1 being the lowest score and 5 being the highest score. These report cards are merely intended as an illustration of how to quickly evaluate a particular case study and apply the principles outlined in this chapter to a real world example. The "scores" were derived through individual judgments of the author and other members of the Global Agenda Council and do not represent an attempt at scientific precision. Thus, there are reasonable arguments for both higher and lower scores for any particular criterion. There is value, however, in attempting to evaluate in a straight forward manner real world examples of certain climate adaptation investments.

Report Card: Coffee Farmer Resilience Initiative

Topic/Criteria		Description / Assessment
Location / Area		Multiple countries, Central America
Sector		Agriculture
Size ($)		US$ 15 million (approx.)
Scalability		Yes, to the extent private sector and philanthropic funds are available for agricultural supply chain resilience projects. However, coffee's unique characteristics as a high-value, highly traded agricultural commodity may make the project somewhat less scalable vis-à-vis other crops or agricultural practices such as those relied upon by subsistence farmers. ***Assessment: 3***
Impacts on Building Climate Resilience		If successful, the project will help tens of thousands of small-scale coffee farmers adapt to changing climate conditions while strengthening commodity supply chains and facilitating investments in future resilience. Assessment 4
Leveraging Public Finance to Attract Private Finance		Uses combination of public and private capital, with certain public and/or philanthropic dollars earmarked as a first-loss layer via guarantees and subordinated debt. ***Assessment 4***
Essential Criteria	1. Developed in environment that is sufficiently 'certain'	The project serves small-scale coffee farmers in Central American countries that are not necessarily known for their stable and predictable policy environments. However, by harnessing Root Capital's longstanding, deep and trusted relationships with rural growers, farmer cooperatives and large importers/buyers, the project will be able to provide a degree of investment certainty not typically found in such jurisdictions and sectors. ***Assessment: 3***
	2. Generates ROI	The project makes use of innovative financial structures so that providers of subordinated debt and first-loss guarantees are able to generate modest returns while general fund investors see somewhat higher rates of return. Root Capital's track record with similar ventures indicates that the project will likely generate an overall positive return. ***Assessment: 4***
	3. Measurable	Each of the project's key components, including long-term coffee renovation investments and income diversification strategy development, includes quantifiable criteria against which success can be measured. The project has not developed specific metrics to measure the degree of resilience enhancements, but improved climate resilience is an inherent feature of successful renovation. ***Assessment: 3***
	4. Politically attainable	The project aligns the interests of private sector investors, local and national governments and rural, coffee-growing communities such that it faces little or no political opposition. ***Assessment: 5***
	5. Must be environmentally sound	Root Capital does not require the use of organic practices as a prerequisite of financing. It does, however, require the use of generally sustainable agronomic practices, such as: the safe and rational use of approved, non-hazardous agrochemicals, (hazardous defined here as World Health Organization Class 1a or b chemicals, as well as those appearing on the Pesticide Action Network's Dirty Dozen list); the use of appropriate soil management practices; and a basic commitment to the conservation of ecosystems and biodiversity. ***Assessment: 3***
Desirable Criteria	1. In developing countries and LDCs	The project is exclusively focused on the resilience of coffee farmers and cooperatives in developing and least developed countries (LDCs). ***Assessment: 5***
	2. Mechanism to be as open and simple as possible	The project depends on the strength of Root Capital's existing relationships and networks throughout the coffee supply chain, and is by nature somewhat opaque and complicated. However, the project is being explicitly developed to be as open and transparent as possible under the circumstances, and Root Capital has an interest in seeing it serve as a blueprint for other similar initiatives. ***Assessment: 4***
Evaluation		Final ***Assessment: 4***

Case Study 2: The Carlsbad Desalination Project, San Diego County, California

According to a comprehensive study prepared by the California Department of Water Resources, climate change is already causing significant reductions in snowpack in California's Sierra Nevada Mountains and in precipitation throughout the Southwestern United States, including across the greater Colorado River watershed.[24] Both are significant sources of drinking water for Southern California's major population centres, including Los Angeles and San Diego counties, which together are home to over 13 million people. Projected water demand growth over the coming decades, together with climate-induced reductions in freshwater resources, make the development of unconventional sources an essential part of the overall water supply mix for the region and an increasingly important form of climate adaptation.

Currently under construction in northern San Diego County, the Carlsbad Desalination Project consists of a reverse osmosis seawater desalination plant, together with a new 10-mile pipeline to deliver product water to existing San Diego County Water Authority aqueducts. When completed, the plant will have a capacity of 54 million gallons per day, producing 56,000 acre-feet of water per year and making it the largest seawater desalination plant in the Americas. The project developer announced in December 2012 that it had raised the US$ 922 million in financing needed to build the project. Construction on the plant began immediately thereafter, while construction on the pipeline commenced in early 2013.

The project's unique ownership, financing and operational arrangements present several valuable lessons for climate smart adaptation investment. First, the project has been developed and will be wholly owned by a private company, Poseidon Resources, a special purpose vehicle jointly owned and managed by a water infrastructure development firm and an investment management firm. As the project company, Poseidon has been responsible for permitting, designing and building the plant and pipeline pursuant to a variety of subcontracts, discussed below, and has also made a significant equity contribution to help pay for construction of the plant. Both the plant and the pipeline are being built under turnkey engineering, procurement and construction (EPC) contracts with a leading construction company, and will be operated pursuant to a separate operations and maintenance (O&M) contract with the US subsidiary of a major Israeli seawater desalination company. Notably, although not directly tied to the project's finances, the San Diego County Water Authority has already invested approximately US$ 80 million in new facilities and modifications, including major pipeline and other infrastructure improvements, in order to incorporate the project into its existing water systems.

Second, and important for present purposes, the project is being financed through an innovative mix of private and public sources, including a direct equity investment by Poseidon and tax-exempt bonds issued by the California Pollution Control Financing Authority on behalf of obligors Poseidon (plant bonds) and the San Diego County Water Authority (pipeline bonds). Notably, while the pipeline bonds are wholly tax exempt under federal and state law and are expected to cover fully the costs of pipeline construction, the plant bonds will cover only a portion of the construction costs, with the remainder to be financed via Poseidon's equity investment. Furthermore, because Poseidon, a private entity, is the obligor of these plant bonds, they are subject to the federal alternative minimum tax. Nevertheless, the ability to offer tax exempt debt instruments to finance a privately owned and operated infrastructure asset represents a significant advantage to the project. Poseidon has already entered into a 30-year "take-if-delivered" water purchase agreement with the Water Authority requiring minimum annual purchases of 48,000 acre-feet at fixed and variable prices, scheduled monthly to allow for seasonal plant flexibility. The project's fixed costs, including bond debt service, will be amortized over these guaranteed purchases.

Third, as a condition of project approval by the California Coastal Commission, Poseidon agreed to account for and reduce to zero the net indirect greenhouse gas (GHG) emissions associated with the project. Poseidon will operationalize this unprecedented commitment through a variety of measures developed pursuant to its Energy Minimization and GHG Reduction Plan written and revised with the input of, inter alia, the Coastal Commission, the California State Lands Commission and the California Air Resources Board (CARB), which also administers the state's cap-and-trade program. The Plan prioritizes, to the extent practicable, energy efficiency measures and on-site renewable energy generation at the Plant, but also anticipates procurement of carbon offsets and/or renewable energy certificates (RECs) to reach the Project's net zero emissions goal.

The Plan thus includes detailed procedures for carbon offsetting. Poseidon shall acquire offsets through/ from the CARB, California Climate Action Registry (CCAR), or California Air Pollution Control District/ Air Quality Management District (APCD/AQMD)-approved projects. Acquisition of RECs are however not limited to purchase from CCAR, CARB or California APCD/AQMD-approved projects. Poseidon may propose purchasing other offset projects, subject to Executive Director or Commission approval, in the event that sufficient offsets are not available from CCAR/ CARB/California APCD or AQMD at a price that is reasonably equivalent to the price for offsets in the broader domestic market. Offset projects that Poseidon implements pursuant to this Plan will be those approved by CARB, CCAR or any California APCD/AQMD as conforming to Assembly Bill (AB) 32 requirements. Poseidon is committed to acquiring cost-effective offsets that meet rigorous standards, as detailed in its plan.

By requiring adherence to robust principles, practices and performance standards, the Plan is designed to assure that selected offset projects will mitigate GHG emissions as effectively as on-site or direct GHG reductions. Adherence will ensure that the offset projects acquired by Poseidon are real, permanent, quantifiable, verifiable, enforceable, and additional, consistent with the principles of AB 32. Poseidon intends to approach REC procurement through emission reduction purchase agreements (ERPAs). In many ways, then, the project will be breaking new ground in both climate change mitigation and adaptation finance.

While the Plan was first publicly released in 2008, many components have yet to be fully implemented as project financing closed only in late 2012 and Poseidon continues to explore the most innovative, cost-effective means by which to mitigate the Project's GHG emissions while pioneering a precedent-setting model for major infrastructure project finance making use of climate-smart adaptation principles.

Report Card: Carlsbad Desalination Project

Topic/Criteria		Description / Assessment
Location / Area		San Diego County, California, USA
Sector		Water infrastructure
Size ($)		US$ 1 billion (approx.)
Scalability		Reasonably scalable to the extent private sector funds are available for major infrastructure projects. Its net zero target is somewhat less scalable in other jurisdictions due to California's unique political/policy context. Assessment: 4
Impacts on building climate resilience		The project is a direct solution to perhaps the most threatening consequence of climate change -- reduced access of vulnerable populations to potable water. ***Assessment: 5***
Leverages public finance to attract private finance		Utilized a combination of public and private monies, as well as innovative public financing tools, such as tax-exempt bonds. The public support for this privately financed project is a good example of how governments can work with the private sector. Assessment: 5
Essential Criteria	1. Developed in an environment that is sufficiently 'certain'	The project is under development in California, where it benefits from a range of local, state and federal policies, tools and instruments that enable the private sector to invest in a major, multi-year infrastructure project with a high level of confidence. Similar projects, at similar scales, may be less attractive to private sector investors operating in jurisdictions with less policy certainty. ***Assessment: 4***
	2. Generate ROI	The project is all but guaranteed to generate a positive ROI for its tax-exempt bondholders and, if successful, will also generate returns for equity holders such as the project sponsors, partners and other affiliated investors. Similar projects could be developed in other jurisdictions using a similar mix of public and private financing. ***Assessment: 5***
	3. Measurable	The project's climate impacts, both in terms of mitigation and adaptation, are to be quantified and tracked, including through the monitoring, reporting and verification requirements imposed under California's climate change reporting and cap-and-trade programs. ***Assessment: 5***
	4. Politically attainable	California's unique political environment includes popular support for GHG mitigation and forward-thinking adaptation measures, making the project, and the plan, more feasible than it otherwise would be in other parts of the US. ***Assessment: 3***
	5. Environmentally sound	The project is being developed in a relatively stringent environmental regulatory context. Although not explicitly required under state or federal law, the plan's net zero emissions goal was incorporated into the project's permit granted to it by the California Coastal Commission, effectively making the offsetting of GHG emissions a condition for regulatory approval. ***Assessment: 4***
Desirable Criteria	1. Activities to be carried out in developing and least developed countries	Political, regulatory and economic factors which make the project feasible in California may not be easily replicated in developing countries and LDCs. In particular, the willingness of bond investors to deploy capital in LDCs is limited. However, there may be some jurisdictions where MDBs and ECAs can fulfil roles analogous to those played by California regulators in the context of this Project. ***Assessment: 2***
	2. Mechanism to be as open and simple as possible	Major infrastructure project finance is by no means simple, with high barriers to entry and a relatively opaque process by which interested stakeholders, whether government actors or private investors, can get involved. Moreover, the project's unique "climate smart" characteristics must be understood in the context of California's unique policy framework. That said, project finance is a well understood and easily replicated mechanism, which is already being deployed in most countries around the world, including many developing countries and LDCs. ***Assessment: 3***
Evaluation		Final ***Assessment: 4***

Options for Private Sector Vehicles to Finance Climate Resilience

Inadequacy of private sector finance vehicles has been well recognized as a major barrier to scale up investment in climate resilience today. The following ideas are presented to trigger additional research and development:

- *Securitizing Insurance Premium Savings:* Explore if a securitization vehicle could draw from future savings in insurance premiums to provide current financing for the incremental costs of building climate resilience. The idea is similar to the current financing being employed in the energy efficiency area. Banks are starting to lend to building owners for capital improvements to reduce energy costs and improve efficiency where the debt service is merely the future savings in energy costs. Thus, as an example, the borrower spends no up-front cash to obtain the financing to retrofit its building to achieve the energy savings. Once the capital improvements are installed, the building saves roughly 30% per annum on energy bills. Instead of taking all of the savings, the borrower uses the savings to service the debt, which is amortized over 15-20 years. As the debt service is less than the savings, the borrower remains cash flow positive throughout the life of the loan.
- In the adaptation finance area, the same concept would apply, but energy bill savings would be substituted for insurance premium savings. There are other issues that would need to be resolved before this could be considered a potential option, but in theory it is viable.
- *Creating Adaptation Tax Credits:* This approach is akin to the current Production Tax Credit or New Market Tax Credit for renewable energy generation and investments in low-income areas, respectively. In each case, the tax credits attract private “tax equity” investors. A government would enable a developer of an adaptation project (however defined) to create adaptation credits based on a defined set of measurable metrics (to be determined) and those tax credits could be used by any company with a tax liability to that government to offset such liability. A project developed anywhere in the world (and perhaps prioritizing developing countries) could yield a tax credit in the country where the tax equity investor has a tax liability.
- *Loan Guarantees/Credit Enhancements:* Borrowers could receive reduced interest rates on loans for adaptation enhancements to properties meeting certain criteria approved by government. If the adaptation enhancements were approved (such approval requiring an entity or entities to be identified with adequate expertise, information and knowledge, among other things), the government would provide credit enhancement to reduce the interest rates (or enable the borrower to obtain the loan in the first instance).
- *Vulnerability Reduction Credits:* The Higher Ground Foundation is promoting the concept of creating a market for "VRCs" much like the carbon markets. Further development of this concept would be required before it could be considered likely to lead to scaled private sector investment as compared with the other potential options.

Further work

Based on the literature and cases reviewed for this chapter (see Appendix B and C), three areas for further work may be identified:

1. Establishing indicative criteria that a private sector adaptation finance mechanism will need to satisfy in order to be replicable and scalable. As adaptation covers a diverse range of actors and sectors, "one size fits all" criteria are not viable. There is a need to identify metrics associated with the incremental costs of building enhanced climate resilience, taking into consideration regional variations both in terms of climate change and its impact;
2. Assessing existing projects against the indicative criteria identified, as such case studies improve understanding of how indicative criteria may be useful in practice;
3. Developing conceptual "straw man" proposals for additional adaptation investment mechanisms for the private sector.

Chapter 4: The Effects of Climate Change on the Water-Food-Energy Nexus

By Rabi Mohtar, Executive Director, Strategic Projects, Qatar Foundation/Texas A&M University, and Sean de Cleene, Senior Vice-President, Global Initiatives, Strategy and Business Development, Yara International

The water-energy-food nexus is the inextricable link between food, energy and water systems, where the use of and strains on one of these resources can affect the other. For example, a drought can lead to increasing food prices, or to power plants, which need water to function, shutting down. Similarly, water production, distribution and treatment are all energy intensive functions and can be affected by energy shortages and pricing. Climate change today is placing increasing stress on this nexus. The major hike in food prices in 2008, for instance, was due to changes in weather patterns which led to water shortages and hence food shortages.

However, despite the evidence for these linkages between water, food and energy systems, and the need for an integrated approach to address the impact of climate change on the nexus, "silo thinking" prevails worldwide, e.g. solutions are presented for increases in energy production that don't take account of their impact on water or food supply or the environment. This will have to change if the challenges of the future are to be adequately met. A transformational, multi-sector and multi-scale approach will have to be adopted.

The problem: How climate change is affecting the nexus

The complexity of the problem that we face today is daunting. Each part of the nexus impacts and depends on the other. Energy is needed to treat and transport water; water is needed to produce electricity and transport fuels; while energy and water are needed to produce food and the quality of that water can be affected by food and energy production.[25] The scale of these connections can be huge. Just one example illustrates this – moving and treating the water in California consumes 20% of the state's electricity production.[26]

Climate change is placing stress on these links. During the drought in the US in 2012 corn crops died due to lack of rain, which reduced food and livestock feed supplies and raised prices. Power plants had to either shut down or reduce production because the water in rivers, lakes and estuaries had got too hot for it to be used for cooling.[27] In addition, shortages of rainfall meant groundwater supplies had to be depleted further, which increased demand for the electricity that was needed to run the pumps. Similar power plant shutdowns were seen in Spain, Germany and France in 2006.[28]

The availability of global water resources, and especially freshwater, has already become critically compromised in large areas. The area of land classified as very dry has more than doubled since the 1970s.[29] However, adaptation to these challenges itself can be very energy intensive: "irrigation requires more energy than rainfed agriculture, desalination more than conventional water supplies, and increased groundwater use and water storage may require additional pumping."[30]

Future impacts of climate change on agriculture and water sectors

The impacts that climate change will have on the agriculture sector are heterogeneous and will vary significantly by region. The magnitude and distribution of impacts are uncertain but all projections show a negative effect in the long term. This is projected to impact agriculture not only in terms of the capacity to produce more food to meet ever-increasing demand but also in the stability of, access to, and utilization of food products. The agro-ecological conditions will directly affect the suitability of land for agricultural use and the yields of crops and livestock.

Mountain glaciers, which serve as sources of water for rivers and billions of people (2 billion in Asia alone), are melting and at current rates these sources of freshwater may disappear by the end of the century.[31] This can cause further major hikes in food prices such as the one in 2008, which was partly due to climate and weather variability, which affected water supplies and consequently food production.

Temperature rises in temperate latitudes are expected to bring about an increase in agricultural land, with longer growing periods and higher yields. In semi-arid and arid regions however, the increased evapotranspiration (the movement of water from plants and soil to the air) and lower soil moisture due to higher temperatures is likely to result in a decrease in the amount of land available for agricultural use, reduced livestock productivity and increased livestock mortality.[32] In areas where there is stress on water resources, or rising temperatures, or a combination of the two, crops such as cereal can become very vulnerable, susceptible to even minor changes.

Mounting concentrations of atmospheric carbon dioxide (CO2) can increase the yields of some crops by up to 20%; at the same time, however, the nutritional value of such produce may be lower. The impacts from higher CO2 are highly dependent upon crop type and management type but it is estimated that yields will fall overall with temperature increases of more than 3°C. Also, the effects that rising temperatures and CO2 may have on increasing numbers of pests, weeds, and extreme events and their interactions are not yet well understood, and diseases and pathogens impacting food production could increase.[33]

The effects of the doubling of atmospheric CO2 concentrations have been simulated to assess the global impact it would have on crops, especially cereal production. Even with the expected rise in yields, the overall impact will reduce global crop production with developing countries bearing the brunt.[34] The higher incidence of unpredictable extreme events is likely to affect more areas. Droughts and floods in semi-arid and sub-humid areas will become more severe and more frequent, dramatically reducing crop yield and livestock numbers.

Turning to the water sector, by the 2050s, the area of land subject to increasing water stress due to climate change is projected to be more than double that with decreasing water stress.[35] Most projections agree that precipitation will increase in high latitudes and parts of the tropics, while it will substantially decrease in lower mid-altitude regions (arid and semi-arid).

Other impacts of changes in the mean climate, such as the increase of extreme events and rising temperatures, will also have a direct effect on the availability of water resources. However, several studies have concluded that the rapid changes in population and socio-economic development over the next two decades will have a much stronger and immediate effect on water and food security than the changes in climate, making them as important to consider.[36]

The impact of climate change on energy use is no less dramatic. The energy consumption required by buildings to cope with the higher temperatures, or to provide additional water in the face of declining groundwater tables, is expected to increase significantly in the future. The new infrastructure investments that this will entail, and the affordability of the same, will also pose additional adaptation risks and challenges, especially for the poorer and more vulnerable sections of society.

Measuring the challenge

The impact of climate change on the nexus must be explicitly defined in order to enable it to be quantified. Further, supply of water, food and energy has historically relied on basic principles of predictability and stationary responses where, for example, measuring past events of weather patterns was a means for adequate future weather forecasting. However, knowledge of the nexus, in the face of a changing climate, is today limited, as data, processes and integrated decision aid tools are lacking (for example, metrics regarding the status of water resources) and a stationary response and past knowledge bases may no longer be reliable. Further work is therefore required to set out and refine metrics to better understand and quantify the problem. One example in this direction that can help in more effective and integrated planning is the water-energy-food nexus tool: http://wefnexustool.org.

Taking action

Solving these complex nexus-related issues is clearly beyond the scope of governments or companies or NGOs on their own. Cross-sector impacts may be poorly understood and existing behaviour may no longer be sustainable. For example, in recent negotiations with state regulators to get the water they need for cooling, one solar thermal plant requested 4.9 billion litres, or 20% of the water in the local valley.[37] All actors must be aware of the issue and adjust their behaviour accordingly, emerging from their “silos” to work together on a common approach to resource use.

To take another example, while developing policies and practices on water security, the most prominent stakeholders, the farmers, are often ignored. If the farmers manage the bulk of fresh water, water security implementation will be handicapped without their participation. The various actors that need to be considered in the nexus include governments, technology providers, civil society and the private sector.

Barriers to sustainable resource management, including policies and public engagement, must be fully explored and overcome.[38] Better understanding should be obtained of the full life-cycle footprint of food, water and energy resources and their products and services. Importantly, measures that reduce demand must be preferred to those that increase supply, and must be implemented in a way that acknowledges the connection between the three systems and the impact of climate change. Much of the adaptation measures developed to tackle climate change have so far been reactive, triggered by past or current events. Yet the need is for them to be anticipatory and based on some assessment of conditions in the future.[39]

Opportunities for less water-intensive storage and less energy-intensive irrigation through improved rainfed agriculture and green water and soil management have not been fully realized.[40] One solution is for water-scarce countries to buy fertile land in water-rich countries, and this is already happening in some regions (as the GCC case study below observes).

Holistic and integrative approaches are today needed to identify and assess what actions are required, as are multi-stake-holder information-sharing and decision-making platforms that can help address the multiple challenges associated with the nexus at local, national and regional levels. Such platforms would address trade-offs and inter-linkages among the various natural resources so that address-ing the climate adaptation of one of these resources, e.g. water, does not compro-mise another, e.g. energy. For instance, one imbalance that exists is that three of the world's top-10 food exporters are actually water scarce, and three of the top-10 food importers are water rich.[41]

The role of the private sector in promoting sustainable natural resource management and responsible investment is equally critical, especially as this is a new field where investment opportunities are abundant. The private sector must also play a bigger role in research and devel-opment in areas that lend themselves to further business opportunities and technology development/enhancement. A critical component will be to overcome barriers to creating scale, particularly when a shift in business model is re-quired. A key challenge here is therefore the need to assume a longer term and more comprehensive view of sustainable market creation. This will require, as the case study of the Africa Growth Corridors below illustrates, moving beyond the traditional view of public-private partner-ships as one or several organizations leading on a specific partnership, or where a third party proactively orches-trates activity on behalf of a range of parties, with the aim of developing a specific inclusive business model around one particular component of the nexus.

Conclusion

By adopting a comprehensive ecosystem view of sustainable growth and development and leveraging the core competencies of all parties to reach the required degree of scale, a step change from the current norm can be achieved.[42] Certain requirements will however need to be borne in mind:

- The need for alignment around a vision shared by all parties involved
- The critical importance of leadership and the role of champions in fast tracking and catalysing transformational change
- The importance of having a clear roadmap that defines the strategic focus of the transformation that has inbuilt flexibility to allow for on-going learning and realignment
- The need to design, manage and monitor implementation activities and identifying key enablers to drive change in scale
- The importance of developing jointly agreed accountability frameworks

What is clear is that in relation to such transformational partnerships, we are still at an early stage and significantly more work needs to be undertaken. To date, the models that have evolved have seen companies along a given value chain or in a given sector working together to implement a systemic change to a specific part of the nexus. In the future, what will be needed is companies from different sectors aligning and working more closely and systematically to create a more joined-up and effective model at the local level.

Case Study 1: The challenge of resource use in GCC states

The Gulf Cooperation Council (GCC) consists of Qatar, Saudi Arabia, the United Arab Emirates (UAE), Kuwait, Oman, and Bahrain. The countries of the GCC are located in hot, arid areas and have experienced fast economic growth under the following conditions:[43]

- The main natural water resource in GCC countries is groundwater. Groundwater resources are however very limited, its replenishment rates are minimal, especially in Kuwait and Qatar, and it is overexploited. Thus it is now even less available, its quality has deteriorated and its usage for agriculture is decreasing. Other water resources are unconventional. These include desalinated seawater, the processing of which requires extensive use of energy, and under-utilized waste water treatment.
- Extensive amounts of energy are also required for the air-conditioning of buildings, a necessity to sustain life in most GCC countries. Although many member states have abundant energy resources, they are ultimately finite. If consumed excessively, they will no longer prove sustainable in the long run.
- Increasing population and the shortage of cultivated land to grow food (due to the low quantity and quality of groundwater resources) are major concerns in the GCC. According to the World Trade Organization (WTO), the GCC is the biggest importer of food in the world, buying more than 90 percent of its total needs, a considerable increase over the past few years, due to the increase in population and the increasing scarcity of water. This exposes the 36 million people in the region to the mercy of global price fluctuations but also to the fluctuating food policies of the exporting countries, such as a ban on the export of certain food commodities.

The GCC is trying to treat the symptoms of growing food insecurity with new policy approaches. For example, the UAE and Saudi Arabia are developing arable lands and food processing units in several Asian and African countries. However it will be important that such acquisitions, as they go forward, are aligned around a vision shared by all parties involved. It will also be important to have a clear roadmap that combines strategic focus with in-built flexibility to allow for on-going learning and realignment, and respects the need for developing jointly agreed frameworks for accountability.

Case Study 2: The promise of Agricultural Growth Corridors in Africa

Agricultural growth corridors are large areas of underutilized fertile land that have been identified as having the potential to improve productivity. The idea was introduced in 2008 at the UN General Assembly by Yara International, a Norway-based private company, and has since grown into a significant multi-stakeholder initiative involving several countries with clear and committed local leadership and ownership.

Across Africa, rural communities often live in relative economic isolation, with low commercialization of economic activity, as well as a lack of access to basic infrastructure (roads, power, irrigation, safe water and sanitation) and to agricultural markets and market-based services. It is increasingly realized that a comprehensive transformational partnership approach for the development of these areas is required. By making targeted investments and connecting local farmers to existing infrastructure built for the extractive and energy sectors, the concept aims to improve efficiency. It adopts an inclusive business development approach to farming, while using “catalytic” financing as a key mechanism to promote inclusive smallholder farmer-led growth.

To date, the concept has been adopted in Tanzania – the Southern Agricultural Growth Corridor of Tanzania (SAGCOT) – and Mozambique, and is emerging in Nigeria. The concept creates viable business clusters and integrates smallholder farmers into emerging value chains whilst facilitating a range of different public-private partnerships, coordinated investment strategies and government support in an improved enabling environment.

Initially, SAGCOT was developed as an economic engine for growth; however, a strong multi-stakeholder partnership has subsequently emerged to promote a sustainable approach to SAGCOT’s investment ambition in support of a green and inclusive growth strategy for the smallholder agriculture sector in Tanzania. This integrated, layered approach is becoming an increasingly important dynamic in the construction of transformational partnership platforms.

Building on the initial work of the agricultural growth corridors, in 2011 *Grow Africa* was conceived as a partnership platform to accelerate investment for sustainable inclusive growth in African agriculture. Co-ordinated by the African Union Commission, the New Partnership for Africa’s Development (NEPAD) and the World Economic Forum, it aims to connect governments, businesses, investors, smallholders and development partners to advance ambitious win-win agricultural partnership initiatives through a transformational partnership platform approach. Eight countries are currently involved in seeking sustainable private sector investment aligned to national plans through the African Union’s Comprehensive Africa Agricultural Development Plan (CAADP).

In its first year, Grow Africa attracted over US$ 3.5 billion in planned investment with 97 commitments from 62 companies, with 60% in a pilot phase and 40% already in an investment phase. Almost 800,000 smallholder farmers benefitted and approximately 270,000 million tons of commodities were sourced.[44]

With many actors involved in each value chain, boosting agricultural markets becomes a task requiring collective endeavour. Partners from across the public and private sector have focused on specific value chains or geographic areas. They can then, acting in concert, collectively tackle the barriers to achieving sustainable market transformation.

Conclusion

Global climate change is expected to increasingly manifest itself throughout this century. As international agreements and mitigation efforts on climate change have not appreciably slowed global greenhouse gas emissions, nations and communities will need to adapt even as they seek mitigation solutions in parallel. Throughout the past decade, the policy, business and academic communities have begun to pay increased attention to the challenge of adaptation. This is something that will need to be continued.

As described in the previous chapters, successful adaptation efforts will require the development and application of appropriate metrics, methodologies and financing. Metrics will be used to yield useful information on current and future vulnerabilities, risks and opportunities. A structured methodology will enable decision-makers to draw on such metrics to systematically assess risks and identify the most cost-effective climate adaptation investments. Finally, public sector funds can be leveraged to attract private sector investment to scale and expand adaptation solutions. All the above must take place subject to a solid holistic and integrative understanding of a water-food-energy nexus, as investments in one area are likely to have knock-on effects on another.

The amount of investment in adaptation that has taken place so far has been miniscule, and much greater effort is needed. It is hoped that the combination of metrics, methodology and financing that this publication has attempted to review will enable decision-makers, from both the public and private sectors, to better understand these key dimensions of climate adaptation, and to identify and take targeted measures to minimize the adverse effects of this global challenge at the lowest cost to society. It is also hoped that by building greater awareness, it will spark further research on this important topic and catalyse greater investment flows for adaptation.

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Appendices

Appendix A: Glossary of Terms

Adaptation: In human systems, the process of adjustment to actual or expected climate and its effects, in order to moderate harm or exploit beneficial opportunities. In natural systems, the process of adjustment to actual climate and its effects; human intervention may facilitate adjustment to expected climate.

Adaptive capacity: The combination of the strengths, attributes, and resources available to an individual, community, society, or organization that can be used to prepare for and undertake actions to reduce adverse impacts, moderate harm, or exploit beneficial opportunities.

Downscaling: Downscaling is a method that derives local-to regional-scale (up to 100 km) information from larger-scale models or data analyses.

Enabling environment: A set of conditions that enable investment in climate adaptation measures to take place.

Exposure: The presence of people; livelihoods; environmental services and resources; infrastructure; or economic, social, or cultural assets in places that could be adversely affected.

Food security: When all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life.

Impacts: Effects on natural and human systems. In this study, the term 'impacts' is used to refer to the effects on natural and human systems of physical events, of disasters, and of climate change.

Mitigation: Human intervention to reduce the emission of greenhouse gases.

Projection: A projection is a potential future evolution of a quantity or set of quantities, often computed with the aid of a model. Projections are distinguished from predictions in order to emphasize that projections involve assumptions concerning, for example, future socioeconomic and technological developments that may or may not be realized, and are therefore subject to substantial uncertainty.

Readiness: Readiness seeks to measure the ability of a country's private and public sectors to absorb additional investment resources and apply them effectively towards increasing resilience to climate change.

Resilience: The ability of a system and its component parts to anticipate, absorb, accommodate, or recover from the effects of a hazardous event in a timely and efficient manner, including through ensuring the preservation, restoration, or improvement of its essential basic structures and functions.

Vulnerability: The propensity or predisposition to be adversely affected.

Appendix B: Adaptation Finance Document Library

The following table is sorted by date. Where the month of publication is not clearly specified in the document, the month entry in the table is a default value of '01'. (yyyy-mm).The categories are AF or CF. AF denotes an article that is focused on adaptation finance. CF denotes an article that looks more broadly at climate finance.

Report Card: Carlsbad Desalination Project

Title	Date	No. of pages	AF/ CF	Adaptation-Relevant Content
The Climate Adaptation Frontier	2013-03	25	AF	An introduction to the concept of an "adaptation frontier".
Shaping China's Climate Finance Policy, The Climate Group	2013-03	N/A	CF	
World Bank Climate Change Definitions	2013-03	4	CF	The World Bank's interpretation of a number of key adaptation-related definitions.
Climate Finance Options	2013-03	N/A	CF	A database of climate finance options: http://www.climatefinanceoptions.org/cfo/index.php For adaptation-specific content, see: http://www.climatefinanceoptions.org/cfo/cfo_search/type:funding_sources%20category:223
Improving Global Public Goods Supply through Conditional Transfers – The International Adaptation Transfer Riddle	2013-02	35	AF	Focuses on a specific type of international transfer that aims to raise mitigation while also reducing the damages from climate change. Another paper that looks at the synergies between mitigation and adaptation is here: 3163284.
World Economic Forum	2013-01	Various	AF	CSA Metrics - 3160841
SwissRe	2013-01	Various	AF	Adaptation measures are available to make societies more resilient to the impacts of climate change but decision makers need the facts to identify the most cost-effective investments. NY city factsheet: http://media.swissre.com/documents/ECA_New_York_Gov_Factsheet.pdf India Factsheet: 3160899 UK Factsheet: 3160900 Shaping Climate-Resilient Development - a framework for decision-making: 3160901 Enhancing the climate risk and adaptation fact base for the Caribbean: 3160902 Economics of Climate Adaptation (ECA) movie: www.swissre.com/rethinking/climate_and_natural_disaster_risk/shaping_climate_resilient_development.html See also: NYC Special Initiative for Rebuilding and Resilience www.swissre.com/rethinking/climate_and_natural_disaster_risk/Swiss_Re_provides_expert_input_for_New_York_City_study.html http://www.nyc.gov/html/sirr/html/report/report.shtml http://nytelecom.vo.llnwd.net/o15/agencies/sirr/SIRR_singles_Lo_res.pdf Weathering climate change: 3160903
Climate Smart Conservation	2012-10	4	CF	Identifies six "climate smart principles" distilled from various sources.
G2A2 Green Finance Report (Short Version)	2012-10	11	CF	PowerPoint presentation describing the approach and key messages of the "The Green Finance Baseline Report" prepared by the Green Growth Action Alliance.
Monitoring Receipt of International Climate Finance by Developing Countries	2012-08	28	CF	Discusses the challenges faced by three Asian countries: Indonesia, the Philippines, and Vietnam in monitoring finance for climate change.
Special IPCC Report: Managing the risks of extreme events and disasters to advance climate change adaptation	2012-06	594	AF	Discusses the concepts of adaptation and resilience in human and natural systems.
Defining "Mobilized" Climate Finance Solving a Fractal Conundrum	2012-03	19	CF	A definition of "mobilized" climate finance with reference to the priorities of LDCs, SIDS and Africa. .
Adaptation Finance: How to Get Out from between a Rock and a Hard Place	2012-02	21	AF	Discusses the purposes and sources of adaptation finance.
Mapping of Public Financial Flows for Mitigation and Adaptation to Developing Countries	2012-01	28 and 23	CF	Reports on the United National Environment Programme's (UNEP) initiative to demonstrate the size and nature of financial flows for climate change to developing countries. Two reports are included: Bilateral Finance Institutions & Climate Change - A Mapping of Public Financial Flows for Mitigation and Adaptation to Developing Countries in 2010: 3100252 Bilateral Finance Institutions and Climate Change - A Mapping of 2011 Climate Financial Flows to Developing Countries: 3163288

Title	Date	No. of pages	AF/ CF	Adaptation-Relevant Content
Stockholm Environment Institute, Working Paper - 2011	2011-11	30	AF	Analyses whether adaptation can be converted into a uniform and standardized product, with measurable outcomes and benefits that 'buyers' can take credit for.
The Landscape of Climate Finance, CPI Report	2011-10	101	CF	A comprehensive review of climate finance flows with recommendations and a summary of the "dimensions" of climate finance.
Developments in Climate Finance from Rio to Cancun	2011-10	18	CF	A synopsis of climate finance development but with little specific detail on adaptation finance.
Mobilizing Climate Finance	2011-10	56	CF	Paper prepared at the request of G20 Finance Ministers to build on the work of the UN High Level Advisory Group on Climate Change Financing (AGF). Provides an account of the current situation in climate finance with specific reference to adaptation finance, discussing how public finances can, and should, get private finance flowing.
European Commission Scaling Up International Climate Finance after 2012	2011-08	46	CF	Includes a selection of comments regarding adaptation finance and the roles played by both public and private finances as well as insurance and other financial products.
Workstream III Operational Modalities	2011-06	7	AF	Discusses the role of public-private partnerships (PPP) in adaptation with examples. Also considers the issue of combining financing instruments to leverage public and private funds.
Universal metrics to compare the effectiveness of climate change adaptation projects	2011-04	28	AF	A discussion of the implementation and usefulness of metrics, including adaptation metrics, in analysing climate change projects.
Climate Change and Sustainability - Role of Tax as Catalyst for Change	2011-03	28	CF	Briefing from Ernst & Young following a survey that discusses the various government incentives and grants across the globe as well as the accelerated and enhanced depreciation provisions being used to bring about a more resource-efficient and low-carbon economy.
Designing Climate Change Adaptation Policies	2011-02	41	AF	Although a long-neglected concept, this paper seeks to define adaptation and discusses ways in which it can be used.
ICLEI, Financing A Resilient City	2011	48		http://www.iclei.org/fileadmin/PUBLICATIONS/Papers/Financing_the_Resilient_City_2011_Global_Report_ICLEI_WS.pdf
International Climate Financing	2011-02	36	CF	An Ecofys publication, commissioned by KfW Development Bank, discussing the importance of both public and private funds in financing mitigation measures.
Understanding Forest Bonds - A Guide to Raising Up-front Finance for Tropical Forests	2011-01	23	CF	A relatively detailed description of forest bonds.
IFC Papers	2011-01	Various	AF	Hydropower – Nepal 3160763 and Zambia 3160803 Agribusiness – Ghana 3160808 Ports – Colombia 3160817 Manufacturing – Pakistan 3160815
Report of the Secretary-General's High-level Advisory Group on Climate Change Financing	2010-11	66	CF	A well-known and well-publicized report on adaptation funding with case studies.
Work Stream 7 Paper Public Interventions to Stimulate Private Investment in Adaptation and Mitigation	2010-11	35	CF	A non-exhaustive list of what it considers to be mitigation and adaptation activities.
From Climate Finance to Financing Green Growth	2010-11	48	CF	Assesses financing needs of green growth in developing countries, the role of the financing described by the UN High Level Advisory Group on Climate Change Financing and how the climate finance system should develop over the next decade.
Climate Finance Fundamentals	2010-11	4	CF	Reports on the critical issue, as yet unresolved, of the relationship between adaptation finance and official development assistance (ODA) for developing countries.
WRI - Renewable Energy Tax Credits	2010-10	2	CF	A short and simple overview of the US production tax credit and investment tax credit regimes.

Title	Date	No. of pages	AF/ CF	Adaptation-Relevant Content
Tax Cooperation on Climate Change	2010-10	22	CF	A UN scoping paper discussing areas where greater international tax cooperation might enhance the effectiveness of domestic responses to climate change.
A Strategy to Engage the Private Sector in Climate Change Adaptation in Bangladesh	2010-09	49	AF	Provides an in-depth study of how to attract private sector investment.
A Review of Public Sources for Financing Climate Adaptation and Mitigation.	2010-07	55	CF	Outlines a range of views and analyses specific sources regarding climate financing options.
Can Capital Markets Bridge the Climate Change Financing Gap	2010-01	12	CF	Provides a good chart identifying the risks involved in securing climate change finance.
Climate Financing and Development: Friend or Foe	2010-01	43	CF	Addresses the relationship between official development assistance (ODA) and climate finance.
Global Environmental Change - Maladaptation	2010-01	3	AF	Focuses on the concept of 'maladaptation'.
Financing adaptation: matching form with function	2009-12	6	AF	States that there is no formal definition of adaptation by the UNFCCC.
The Little Climate Finance Book	2009-12	91	CF	Provides a comprehensive review of different types of climate finance.
International Adaptation Finance - The Need for an Innovative and Strategic Approach	2008-06	43	AF	A discussion of the ways to scale up the provision of adaptation funds for particular developing countries.
Stockholm Environment Institute: Private Sector Finance and Climate Change Adaptation	2008-01	4	AF	A discussion of the private sector's role and influence in climate change adaptation.
IPCC 2007 - Glossary of Terms	2007-01	70	CF	Provides IPCC's interpretation of a number of key adaptation-related definitions.
IPCC, 2007: Adaptation Summary for Policymakers.	2007-01	7	AF	A summary of the science that influences adaptation decisions and measures.
Inter-relationships between Adaptation and Mitigation	2007-01	34	CF	Identifies four types of inter-relationships between adaptation and mitigation.
Adaptation to Climate Change Key Terms	2006-05	25	CF	Provides the OECD's interpretation of a number of key adaptation-related definitions.
Climate Smart Adaptation	2005-01	40	CF	Discussion paper issued by the Queensland (Australia) government inviting Queenslanders to share their views on how to prepare for climate change.
IPCC 2001- Glossary of Terms	2001-01	24	CF	See IPCC 2007 Glossary.

Appendix C: Additional Adaptation Finance Case Studies

Additional Case Study 1: Connecticut's Green Bank: The Clean Energy Finance and Investment Authority (CEFIA)

Background

In 2011, the Connecticut legislature passed a law to create the nation's first "green bank" - the Clean Energy Finance and Investment Authority (CEFIA). CEFIA is focused on using limited ratepayer and taxpayer resources to attract private capital investment in clean energy deployment in Connecticut.

Key goals

(i) Attract and deploy capital to finance the clean energy goals for Connecticut;

(ii) Develop and implement strategies that bring down the cost of clean energy in order to make it more accessible and affordable to consumers;

(iii) Reduce reliance on grants, rebates, and other subsidies and move towards innovative low-cost financing of clean energy deployment.

By utilizing subordinated debt and loan loss reserves instead of grants, CEFIA leverages its funds to drive 5 to 10 times as much private investment in clean energy. From July 2012 to June 2013 the CEFIA's activities resulted in over US$ 220 million of investment in clean energy deployment by investing about US$ 20 million of ratepayer and taxpayer capital in various sectors.

Report Card: CEFIA

Topic/Criteria		Description / Assessment
Location / Area		Connecticut, USA
Sector		Clean energy finance in the residential, commercial/industrial, institutional and infrastructure sectors
Size ($)		US$ 100 million (approx.)
Scalability		Where there are institutional frameworks to support the legal structure and where there is a source of capital, such as electricity bill surcharges, the Project is highly scalable. The challenge will be to develop similar institutional frameworks and determine the source of capital in locations that do not have similar capacities to impose surcharges on electricity bills. Moreover, as noted below, applying this model to climate resiliency investments raising further challenges. ***Assessment: 4***
Impacts on Building Climate Resiliency		The Project is not focused on building climate resilience, but rather on expanding clean energy and energy efficiency throughout Connecticut. However, CEFIA is developing a micro grid financing program to support more reliable clean energy deployment across the state as a result of recent natural disasters disrupting the grid and consumer access to power and heat. The interesting question is whether this model could be expanded to include a focus on enhancements to climate resiliency. The remaining question will be what revenue streams exist for climate resiliency investments in which the private sector would be attracted to investing with certain risk mitigation and credit enhancement tools employed by a program similar to the Project. Until that is more clear, the Project and any further examples of the same will likely not focus on climate resilience. ***Assessment 3.***
Leveraging Public Finance to Attract Private Finance		The Project is tailor made to do just that, and the early data suggests that it is having good success in doing so. Current leverage rates of 4.7 to 1 show that the model works. Increasing leverage rates will likely be easier as the Project further establishes track record and the private financial institutions get more comfortable with the project and the investment types it provides for. ***Assessment 5***.
Essential Criteria	1.Environment sufficiently 'certain'	Created by Connecticut law, the Project has a clear legal and regulatory environment. It is a novel approach within the U.S. however, so this has led to the need to market and educate stakeholders from across the financing and project spectrum. ***Assessment: 4***
	2. Generate ROI	The Project's purpose is to enable private sector investments into project types that otherwise might not be feasible at scale. Thus, it takes on certain project risks that the private sector is unable to assume. This innovative role for Government enables the private sector actors to achieve financial returns in these new asset classes. Thus, while the Project itself is only focused on not "losing" money, its mandate is not to make commercial returns, but rather enable the private capital investing alongside the Project to make commercial financial returns. On that basis, it is directly addressing this critical need. ***Assessment: 5***
	3. Measurable	The Project has a very rigorous set of financial, energy, economy, and environmental analytics and is measuring multiple performance indicators. Given that the Project is not focused on catalysing climate-friendly investments into building resiliency, it is currently difficult to say how such adaptation related metrics would be incorporated in to a similar model focused on adaptation. ***Assessment: 3***
	4. Politically attainable	Connecticut is a progressive state with forward looking leaders and an electorate that supports such leadership. The Project is successful in its state and there are a number of other states now following Connecticut's lead. This type of model is likely to be widely acceptable across most developed country jurisdictions. The challenge will be how to implement and adapt this model in the developing country context. ***Assessment: 3***
	5.Environmentally sound	The Project is set up to enhance clean energy and energy efficiency projects throughout the state. It is thus a strong environmental benefit to the state. ***Assessment: 3***
Desirable Criteria	1. Carried out in developing countries and LDCs	The political, regulatory and economic factors which make the Project feasible in Connecticut may not be easily replicated in developing and least developed countries. In particular, the source of capital to fund the Project needs to be determined, as many developed countries and most LDCs may not have the ability to add a surcharge to electricity bills and may not have a consumer base of electricity large enough for such purpose, even if they could impose such charges. This could be a role for the GCF or other MDBs. ***Assessment: 2***
	2. Mechanism as open & simple as possible	Dollars invested, projects developed, performance results and future goals are all very well tracked and reported. Continuing education on the opportunities presented by the Project for both private investors and end-consumers of the investments is an ongoing need. ***Assessment: 3***
Evaluation		Final ***Assessment: 4***

Additional Case Study 2: Kilimo Salama Programme, Kenya/Rwanda

One of the weather index insurance programmes supported by GIIF is "Kilimo Salama", which literally means "safe farming" in Kiswahili, the language spoken in much of northern Kenya (http://kilimosalama.wordpress.com). The programme is a partnership between the Syngenta Foundation for Sustainable Agriculture, local mobile phone operator Safaricom, local insurer UAP and Swiss Re Corporate Solutions. It insures the cost of inputs (seeds, fertilizers) and the expected value of farm harvests, covering yield shortfalls due to insufficient or excessive rain. Swiss Re Corporate Solutions reinsures the programme and provides actuarial support to price the insurance cover. Since its launch as a pilot with 200 farmers in 2010, Kilimo Salama has seen strong growth: in 2012 it provided weather insurance protection to 53,000 farmers in Kenya and covered crops such as maize, wheat, beans and sorghum. An important reason for Kilimo Salama's success is that it uses mobile phone technology to speed up access and payouts to rural farmers, through Safaricom's well-established and trusted M-PESA mobile money transfer service. In 2012, the programme was successfully expanded to Rwanda, where it covered 21,000 farmers by the end of the year. Due to adverse weather conditions, there were payouts in both countries in 2012: in Kenya 7,800 farmers received a total of US$ 541,000, and in Rwanda 1,600 farmers were paid US$ 10,300.

Additional Case Study 3: MiCRO, Haiti

The devastating earthquake that struck Haiti early in 2010 was one of the worst natural catastrophes in recent years, causing terrible human suffering and killing over 220,000 people. It also destroyed the livelihoods of numerous grassroots entrepreneurs, because they did not have any insurance protection against the consequences of such natural disasters. In view of this situation, Swiss Re partnered with Fonkoze (www.fonkoze.org), Haiti's largest microfinance institution, and Mercy Corps (www.mercycorps.org), to develop the Microinsurance Catastrophe Risk Organisation, MiCRO (www.microrisk.org). MiCRO's first product (named Kore W which means "for you" in Haitian Creole) is specifically targeted at the informal sector in Haiti – Fonkoze's almost 60,000 female clients who have set up small businesses to provide for their families and improve their economic situation. As Haiti is highly vulnerable to natural disasters, having access to insurance protection is vital for

Report Card: Kilimo Salama Programme

Topic/Criteria		Description / Assessment
Location / Area		Kenya and Rwanda
Sector		Agro, smallholder farmers, covering yield shortfalls due to insufficient or excessive rain.
Size ($)		Covers 53,000 farmers in Kenya and 21,000 farmers in Rwanda.
Scalability		Since its launch as a pilot with 200 farmers in 2010, Kilimo Salama has seen strong growth, CAGR of > 1,800%.
Impacts on Building Climate Resilience		Due to adverse weather conditions, there were pay-outs in both countries in 2012: in Kenya 7,800 farmers received a total of US$ 541,000, and in Rwanda 1,600 farmers were paid US$ 10,300.
Leveraging Public Finance to Attract Private Finance		-
Essential Criteria	1. Developed in environment that is sufficiently 'certain'	Both premium and claims payment vie mobile phone. Parametric trigger.
	2. Generate ROI	NA - an insurance product.
	3. Measurable	See figures above.
	4. Politically attainable	See 1.
	5. Environmentally sound	No environmental harm – to the contrary, stabilizes agricultural yields.
Desirable Criteria	1. Activities to be carried out in developing and LDCs	Designed for least developed regions, smallholder farmers.
	2. Mechanism to be as open and simple as possible	Quite simple, all a farmer needs is a mobile phone
Evaluation		

Report Card: Microinsurance Catastrophe Risk Organisation (MiCRO)

Topic/Criteria		Description / Assessment
Location / Area		Haiti
Sector		Microfinance
Size ($)		Covers Fonkoze's almost 60,000 female clients who have set up small businesses to provide for their families and improve their economic situation.
Scalability		Scaled very well and fast within Fonkoze.
Impacts on Building Climate Resilience		MiCRO proved its worth in 2012 when Tropical Storm Isaac and Hurricane Sandy brought destruction to Haiti yet again. MiCRO provided US$ 4.7 million in cash pay-outs and loan cancellations to a total of 27,949 beneficiaries out of the 60,000 Fonkoze clients.
Leveraging Public Finance to Attract Private Finance		-
Essential Criteria	1. Must be developed in an environment that is sufficiently 'certain'	Fonkoze is Haiti's largest microfinance institution
	2. Must generate a return on investment	An insurance product
	3. Must be measurable	See figures above
	4. Must be politically attainable	See 1
	5. Must be environmentally sound	No environmental harm
Desirable Criteria	1. Activities to be carried out in developing and least developed countries	Designed for least developed regions, covering (micro)loans of small businesses
	2. Mechanism to be as open and simple as possible	MiCRO's key innovation is that it combines a parametric cover with a basis risk cover, which enables it to closely mirror the actual damage on the ground
Evaluation		

these micro-entrepreneurs to recover after a catastrophic event and to gradually build better, sustainable lives.

MiCRO's key innovation is that it combines parametric cover (using a model to calculate the payout of the insurance policy) with a basis risk cover, which enables it to closely mirror the actual damage on the ground. This means that MiCRO can offer effective, accurate protection to the insured micro-entrepreneurs and their families. At the same time, the solution allows Fonkoze to respond quickly to the problems faced by their clients and helps them remain solvent. The programme covers earthquakes, hurricanes and excess rainfall. In Haiti, when the Kore W product is triggered, the insured micro-entrepreneurs benefit in three ways: they receive an emergency payout in cash (a fixed sum of 5,000 Haitian Gourdes, the equivalent of US$ 125), their outstanding loan balance with Fonkoze is cancelled, and they receive a new loan under the same terms once they are ready to resume their commercial activities.

MiCRO proved its worth in 2012 when Tropical Storm Isaac and Hurricane Sandy brought destruction to Haiti yet again. Both storms caused substantial flooding and mudslides, and many micro-entrepreneurs lost their merchandise and/or their homes, especially in the country's south. Isaac and Sandy, together with smaller events in April and June, triggered payouts from MiCRO to Fonkoze. For the whole of 2012, MiCRO provided US$ 4.7 million in cash payouts and loan cancellations to a total of 27,949 beneficiaries out of the 60,000 Fonkoze clients covered by Kore W. Thus, the average amount per case was US$ 168 for the year 2012. Kore W, MiCRO's first product, was launched in 2011. However, MiCRO has been designed as a "scalable" facility that can be extended to other catastrophic risks as well as further countries. MiCRO is currently developing programmes to expand its catastrophe risk solutions to Central America and the English-speaking Caribbean.

Additional Case Study 4: Shoring up Energy Coast – Building climate-resilient industries along America's Gulf Coast

Topic/Criteria		Description / Assessment
Project Name		Shoring up the energy coast - building climate-resilient industries along America's Gulf Coast. An application of the Economics of Climate Adaptation (ECA) methodology.
Location/Area		US Gulf Coast
Sector		Energy utility sector
Size ($)		Investing approximately US$50bn over next 20 years will lead to cUS$135bn in averted loss.
Scalability		The ECA methodology provides decision makers with a fact base to develop a local adaptation strategy. Applicable globally, all hazards, all sectors.
Impacts on Building Climate Resiliency		Driving a practical solution that takes Gulf Coast resilience to the next level represents an optimal solution to balance cost requirements with risks that impact the Gulf Coast. Investing approximately $50bn over the next 20 years in measures with cost-to-benefit ratios of less than 1 will lead to approximately $135bn in averted loss over the lifetime of the measures. Pursuing all potentially attractive actions may involve an investment of c$120bn over the next 20 years, and may lead to $200bn in averted loss over the lifetime of the measures. There needs to be a focus on adaptation to address near-term risks, and mitigation to address longer-term risks. In the near-term, significant impacts from climate change may be "locked in", and will require strong action today (actions should begin with low-cost, "no-regrets measures"). www.swissre.com/rethinking/Building_a_resilient_Energy_Gulf_Coast.html http://media.swissre.com/documents/Entergy_study_exec_report_20101014.pdf
Leveraging Public Finance to Attract Private Finance		Policy makers can and must take a leadership role in driving a coordinated response across individuals and sectors. Policy makers can support and enforce a range of actions to reduce the risks that individuals bear (e.g., through building codes, development decisions). They can also unlock barriers to increasing the resilience of industry (e.g., electric utility and oil and gas sectors).
Essential Criteria	1. Environment sufficiently 'certain'	Clear mandate from decision makers a prerequisite. Here study executed under a mandate from Entergy, a leading energy utility in the region.
	2. Generate a ROI	The methodology provides decision makers with an adaptation cost curve. See 3.
	3. Measurable	The methodology follows a rigorous risk management approach to assess local total climate risk, proposing and prioritizing a basket of adaptation measures to address total climate risk on an economic basis/
	4. Politically attainable	See 1.
	5. Environmentally sound	The methodology integrates climate adaptation with sustainable development. It therefore allows decision makers to integrate adaptation with economic development and sustainable growth. In the specific case, ecosystem services showed to be least expensive yet very effective adaptation measures – similar to findings in the Caribbean.
Desirable Criteria	1. Activities to be carried out in developing and LDCs	Methodology proved in several case studies, majority in developing countries with some in least developed.
	2. Mechanism as open and simple as possible	Methodology is open source, see e.g. the pertinent lecture course at the Swiss Federal Institute of Technology (ETH): www.iac.ethz.ch/edu/courses/master/modules/climate_risk
Evaluation		

Appendix D: References

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