



**Adapting to Climate Change:
Assessing the World Bank Group
Experience
Phase III**

Adapting to Climate Change: Assessing World Bank Group Experience

Phase III of the World Bank Group and Climate Change



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Abbreviations

ACC	adaptation to climate change	LDCF	Least Developed Countries Fund
ACV	adaptation to climate variability	MACC	Mainstreaming Adaptation in Climate Change Project
CCCCC	Caribbean Community Climate Change Centre	MIGA	Multilateral Investment Guarantee Agency
CC	climate change	NLTA	Nonlending Technical Assistance
CCT	Conditional cash transfer	NOAA	US National Oceanic and Atmospheric Administration
CDM	Clean Development Mechanism	OECD	Organization for Economic Cooperation and Development
CEIF	Clean Energy Investment Framework	PCF	Prototype Carbon Fund
CER	Certified emission reduction	PES	Payment for environmental services
CFU	Carbon Finance Unit of the World Bank	PPAR	Project Performance Assessment Report
CO ₂	Carbon dioxide	PPCR	Pilot Program for Climate Resilience
CO ₂ e	Carbon dioxide equivalent	REDD	Reduced Emissions from Deforestation and Degradation
CPACC	Caribbean Planning for Adaptation to Global Climate Change Project	ROE	Return on equity
CPF	Carbon Partnership Facility	SANBI	South Africa National Biodiversity Institute
CV	climate variability	SCCF	Special Climate Change Fund
DDO	Deferred drawdown operation	SFDCC	Strategic Framework on Development and Climate Change
DPL	Development Policy Loan	SIDS	Small island developing states
DSF	Decision Support Framework	SLWM	Sustainable land and water management
ENSO	El Niño/ Southern Oscillation	SPA	Strategic Priority for Adaptation
ERR	Economic rate of return	SPACC	Implementation of Adaptation Measures in Coastal Zones Project
ESMAP	Energy Sector Management Assistance Program	SPCR	Strategic Program for Climate Resilience
FCPF	Forest Carbon Partnership Facility	SREX	IPCC special report on extreme events.
GCM	General Circulation Model	UNFCCC	United Nations Framework Convention on Climate Change
GEF	Global Environment Facility		
GEFEO	Global Environment Facility Evaluation Office		
GFDRR	Global Facility for Disaster Reduction and Recovery		
GIS	Geographic Information System		
IBRD	International Bank for Reconstruction and Development		
IDA	International Development Association		
ICR	Implementation and Completion Results Report		
IDA	International Development Association		
IEG	Independent Evaluation Group		
IFC	International Finance Corporation		
IPCC	Intergovernmental Panel on Climate Change		
IPR	intellectual property rights		
IFPRI	International Food Policy Research Institute		
IRR	Internal rate of return		

Glossary

Adaptation: Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. (IPCC 2007)

Adaptive capacity: The ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences. (IPCC 2007)

Adaptation deficit: The difference between the optimal amount of adaptation to current climate variability and the amount of adaptation that has actually occurred.

Adaptive management: A resource management approach where decisions are updated iteratively as new information becomes available.

Agroclimatic zone: A land unit, in terms of major climate and growing period, that is climatically suitable for a certain range of crops and cultivars. (FAO 1983)

Anticipatory adaptation: Adaptation that takes place before impacts of climate change are observed. (IPCC 2007)

Basis risk: The difference between an index and the risk being insured against that index. For example, the risk that there will be rain at a weather station index but not on an insured farmer's land. [See index insurance.]

Catastrophe Deferred Drawdown Option (Cat DDO): A contingent credit mechanism offered by the World Bank to International Bank for Reconstruction and Development (IBRD)-eligible countries.

Climate-proofing: Actions taken in the design of a project or program to reduce its vulnerability to climate-related risks, including climate change. Does not imply complete elimination of risks.

Climate Smart Agriculture: Agriculture (including fisheries and forestry) that sustainably increases productivity, resilience (adaptation), reduces or removes greenhouse gases (mitigation) while also enhancing the achievement of national food security and development goals. (FAO 1983)

Climate variability: Variations in the mean state and other statistics (such as standard deviations, statistics of extremes, etc.) of the climate on all temporal and spatial scales beyond that of individual weather events. (IPCC 2007)

Current climate variability: The level of climate variability encountered under present-day conditions, as opposed to under future conditions.

Climate change: A change of climate that is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and that is in addition to natural climate variability observed over comparable time periods. (as defined in the UNFCCC, Article 1)

Disaster risk management: Processes for designing, implementing, and evaluating strategies, policies, and measures to improve the understanding of disaster risk, foster disaster risk reduction and transfer, and promote continuous improvement in disaster preparedness, response, and recovery practices, with the explicit purpose of increasing human security, well-being, quality of life, resilience, and sustainable development. (IPCC 2012)

Disaster response: Actions taken in the aftermath of a disaster to ameliorate the impacts of the disaster, potentially including reconstruction efforts.

Disaster risk reduction: Actions taken before a disaster designed to reduce the probability of a disaster from happening or to reduce the damage from a disaster should one occur.

Downscaling: A method that derives local- to regional-scale (10 to 100 kilometer) information from larger-scale models or data analyses. (IPCC 2007)

Exposure: The presence of people; livelihoods; environmental services and resources; infrastructure; or economic, social, or cultural assets in places that could be adversely affected by climate change effects. (IPCC 2012)

Evapotranspiration: The transfer of water into the atmosphere via evaporation and plant transpiration.

Global Climate Model or General Circulation Model: A mathematical climate model that includes atmosphere, ocean, and sea ice.

Hard risk reduction: Risk reduction undertaken through traditional physical engineering approaches, such as dikes, seawalls, and drains.

Hydromet systems: Hydrometeorological systems for recording and analyzing data on hydrology and meteorology, such as river flows, precipitation, and temperature.

Hyogo Framework for Action: A global action plan for reducing disaster losses, adopted at the World Conference on Disaster Reduction.

Index insurance: A form of insurance where payouts are conditioned on an external observable index measure, such as the amount of rain at a particular weather station over a specified period.

Mainstreaming: The process of integrating climate risks and adaptation issues into traditional sectoral development and investment practice.

Maladaptation: Any changes in natural or human systems that inadvertently increase vulnerability to climatic stimuli; an adaptation that does not succeed in reducing vulnerability, but increases it instead. (McCarthy, Canziani and others 2001)

Mitigation: (1) reduction in the growth of greenhouse gases in the atmosphere; (2) when used in the context of climate risks, refers to mitigation of risks.

No-regret actions/Low-regret actions: Actions that provide net benefits under current climatic conditions and under possible future climate conditions. Low-regret actions may not provide net benefits under some possible but unlikely future climate conditions.

Resilience: The ability of a system to resist shocks, particularly climate shocks.

Robust actions: A synonym for no-regret/low-regret actions.

Robust decision making: A decision-making technique that emphasizes reducing the potential for regret by selecting options that perform well over a large set of possible future scenarios.

Safety net: A social program designed to provide cash or non-cash benefits to those affected by negative shocks.

Soft risk reduction: Risk reduction undertaken through ecologically based methods, including use of wetlands to reduce flood risk, planting trees or other vegetation to reduce landslide risk, and planting mangroves to protect coastal areas from storm surge.

GLOSSARY

Sustainable land management: A knowledge-based procedure that helps integrate land, water, biodiversity, and environmental management (including input and output externalities) to meet rising food and fiber demands while sustaining ecosystem services and livelihoods. (World Bank 2006)

Vulnerability: The degree to which a system is susceptible to and unable to cope with the adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity. (IPCC 2007)

Transformational change: A dramatic state of change, after which current activities may no longer be feasible.

Yield gap: The gap between actual and achievable yields of a staple crop.

Preface

This constitutes the third and final volume of a series of assessments of the World Bank Group's engagement with climate change issues. The first focused on World Bank involvement in policy issues related to greenhouse gas mitigation. It was mainly concerned with the potential for energy price reform and energy efficiency policies to yield dividends in growth, fiscal savings, and climate change mitigation. The second volume examined project-level lessons related to greenhouse gas mitigation.

This volume draws lessons from World Bank and IFC engagement in climate change adaptation. Like its predecessors, but to an even greater extent, this evaluation has a strong focus on learning, as the Bank Group explores a newly defined agenda. Climate change adaptation has only recently captured widespread policy attention. In strong contrast to climate mitigation, whose progress can be tracked along a single global metric (the atmospheric concentration of greenhouse gases), adaptation takes many forms, is intensely local, and resists easy definition and measurement. To a much greater extent even than climate change mitigation, adaptation is intertwined with development. Thus this evaluation looks not only at activities explicitly labeled "climate adaptation" but also at a selection of those that might be expected to be adaptive, even if not so labeled.

A forthcoming capstone summary will synthesize the climate series.

Acknowledgments

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Statement of the External Advisory Panel

Climate change and climate variability poses big risks, but also opportunities, for development. If unchecked, in some cases, climate change could reverse many of the development achievements of recent decades. Preparing to manage and reduce climate risks is therefore an essential part of development in the 21st century.

There are two generic response options. Mitigation addresses the causes of climate change by reducing greenhouse gas emissions. Adaptation deals with the consequences of climate change by reducing our vulnerability and exposure to the risks associated with climate change, climate variability and extreme climate events. Mitigation usually captures the headlines, but the two responses are equally important.

Coping with adverse climate conditions has been a defining challenge of human existence since the beginning of time. However, in its extent and form, adaptation to anthropogenic climate change is a new and challenging agenda. Adaptation is particularly notable for low-income countries, where vulnerability to climate change is invariably high and adaptive capacity often constrained.

Against this background we welcome the report by the Independent Evaluation Group (IEG) on adaptation to climate change in the World Bank Group. The IEG team has produced a detailed, thorough and insightful report that provides a fair assessment of the Bank's adaptation performance to date. The report contains a number of important recommendations that will help the Bank to enhance its operational effectiveness on adaptation.

Adaptation is a very broad agenda. The IEG team struggled initially to define the scope of their evaluation. Many aspects of development assistance have the potential to alter (either positively or negatively) vulnerability to climate variability and change – rural development, health and sanitation, water supply, infrastructure, trade policy, institution building, disaster management, and much else. Ultimately the IEG team found the right balance between inclusiveness and analytical focus for the purpose of this evaluation. However, it is worth noting that the need to factor climate risks (both current risks and increased risks from climate change) into project decisions and development strategies, particularly for the long term, goes beyond the core areas covered in this report.

As the IEG report notes, there are risks of under-investing in adaptation in some areas while simultaneously over-investing in others. A key challenge is to identify the most promising opportunities considering likely benefits, costs, institutional

constraints and existing in-country activities. The IEG report is appropriately structured around the key priorities identified in the adaptation literature and increasingly adopted in adaptation practice. They are:

- A focus on win-win adaptations that reduce vulnerability to both current climate variability and future climate change. Most measures under this heading are closely linked to development and as such familiar to the Bank. They address existing adaptation gaps, for example on disaster preparedness and disaster risk reduction, micro-insurance, water management and agricultural practices. It is also worth recalling that fundamental development assistance on literacy, education, health and poverty eradication tends to be associated with higher adaptive capacity and lower vulnerability to climate change.
- An awareness of climate risks in strategic decisions that, if not effectively implemented, may lock in adverse vulnerability profiles for the long term. Examples include planning decisions (e.g. on development in hazard zones), investment decisions (e.g. in climate sensitive activities like agriculture) and infrastructure design (e.g., the siting of roads). The requirement is not to climate-proof all these investments upfront. Given the high degree of uncertainty about future climate outcomes this is not possible. But decisions need to be climate-aware, rational in the face of potential climate risk and able to respond when those risks materialize. Decision-making should also be as robust as possible to enable flexible and resilient adaptive management over time.

Tellingly, the IEG report has much more to say about the first issue, dealing with current vulnerability. On this it provides a wealth of information on the Bank's performance and makes concrete recommendations on how operational performance might be improved. This is where the Bank's comparative advantage as a development institution lies. We support the conclusions drawn in the report, for example on the importance of financial sustainability in adaptation schemes (including for maintenance), the challenge of setting up sound institutions, the risk of inadvertent maladaptation, and the broad (but not universal) value of financial products for risk management.

IEG's recommendations on the second issue, strategic positioning, are more conceptual, less detailed and less well grounded in operations. This reflects the fact that climate-aware, robust decision-making in areas such as land planning and infrastructure design is still rare, not just in the Bank but the development community in general (and indeed in advanced countries also). Yet, the report is right to call for more strategic thinking in selecting anticipatory adaptation projects. Apart from a few transnational (e.g. basin-level water management) programs,

anticipatory adaptation projects have often been for relatively small time and spatial scales, for which climate variability tends to be much larger than climate trends. It is therefore unsurprising that few examples of anticipatory adaptation exist. IEG is right to recommend more emphasis on long-lived decisions such as land use planning, and could have equally emphasized regional to global investments such as in agricultural research and genetic resources. Although these are a relatively small part of the Bank's overall portfolio, they may provide the most immediate opportunities for anticipatory adaptation.

Some of the report's most important recommendations concern the need to learn. Learning is a key focus of the evaluation and rightly so. Our capacity to adapt will improve only if we can absorb the concrete lessons that emerge from practical adaptation programs, including the extensive cohort of coping and adaptation experiences related to climate variability and disaster risk reduction. The IEG report (besides adding its own lessons to the body of knowledge) makes crucial recommendations on the need to build learning much more systematically into adaptation programs. Many of the Bank's adaptation projects are labeled as pilot programs, which makes it essential that lessons (both positive and negative) are distilled and learned as a matter of course. Appropriately evaluated, initiatives such as the Pilot Programme on Climate Resilience can offer rich insights into both climate variability and anticipatory adaptation, which could be fed into the development of a crisper strategic direction for adaptation. To date, too many pilot programs have failed to generate clear lessons.

The IEG evaluation focuses rightly on the Bank's own performance in its lending decisions and adaptation choices. However, it is worth remembering the wider policy context in which adaptation takes place and the emerging framework for international adaptation support. They have important repercussions for the Bank's future approach to adaptation.

Under the United Nations Framework Convention on Climate Change, developed countries have pledged to provide climate finance of up to US\$ 100 billion a year by 2030. This is almost as much as the current level of official development assistance and much of it will be earmarked for adaptation. The origination, governance, and management of these funds raise complex questions. The Bank has an important role in this debate, and indeed has played a leadership role in the provision of fast-start climate finance through the Climate Investment Funds, which include adaptation. However, it is clear that the institutional landscape on adaptation finance will become more complex, more diverse, and perhaps more competitive in the future. New organizations are likely to emerge with core mandates in adaptation support. The Bank will have to position itself in this new institutional landscape.

STATEMENT OF THE EXTERNAL ADVISORY PANEL

No development institution can ignore the risks posed by climate change. The Bank is well aware of this reality. As the IEG report demonstrates, the Bank has a good track record as an implementer of adaptation projects. It has also made progress in integrating climate vulnerability into country assistance strategies. However, the report is right when it talks about “unresolved challenges” in incorporating climate risks into project design and appraisal. Much more remains to be done in particular to ensure there is sufficient capacity and support to populate and sustain institutions and appropriate technologies for long-term adaptation planning and implementation. The adaptation challenge has only just started.

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Overview

Adapting to Climate Change

Highlights

Adaptation to climate variability—such as floods, storms, and droughts—is an old and unfinished agenda. It overlaps partially with a newer agenda, adaptation to climate change. Climate change involves both intensification of existing climate variability and the emergence of wholly new challenges, such as sea level rise. This evaluation draws lessons from World Bank Group experience with both forms of adaptation.

The Bank Group's "Strategic Framework for Development and Climate Change (FY09-11)," ushered in a substantial increase in attention to climate adaptation in country and regional strategies, in analytic work, and in funding for integrated national-level investment plans. Three pioneering projects, initiated before the Strategic Framework, provide lessons for this new batch of efforts: the importance of focusing, initially, on a few critical issues; of combining action with planning; and of placing responsibility for climate change coordination with a powerful agency. These projects, along with most country strategies, focus strongly on adaptation to climate variability even where severe long-term climate change impacts loom.

Climate variability and poverty are acute in areas of rainfed agriculture. Some evidence suggests that sustainable land and watershed management projects have boosted incomes in such areas. Resilience benefits are presumed, but must be verified, as there are examples of maladaptive impacts—as when inappropriate afforestation depletes groundwater. There has been some success with drought mitigation and relief projects, but weather index insurance for households has not yet fulfilled hopes that it could be a major risk management tool. In irrigated areas, new techniques for monitoring actual water consumption may provide a tool for institutions to manage water—critical, since irrigation accounts for 86 percent of human water use, and water stress will increase.

The Bank has innovated in financial products for disaster risk management, meeting clients' need for emergency liquidity through stand-by loans and insurance pools. But financial products are not available anywhere to more fully manage risks of catastrophic losses. In recent years, the Bank has shifted emphasis from disaster relief toward disaster risk reduction. These investments have often succeeded, but face problems of financial and physical sustainability. The Bank has also supported the development of hydrometeorological systems, more extensively and successfully in middle-income countries than in Sub-Saharan Africa where systems often function poorly.

Long-lived, inflexible infrastructure projects are often subject to climate risk, but the Bank Group lacks procedures for identifying and mitigating these risks. Climate models have proved less useful than hoped for in identifying adaptation options, suggesting the need for more attention to decision making under extreme uncertainty.

Anticipatory adaptation efforts—pay now to avoid damages later—are inherently less appealing to individuals and to countries because of the uncertainty surrounding benefits, and because urgent current needs trump future ones. Land use planning stands out as potentially important for reducing future exposure to extreme weather and for assisting in biodiversity conservation. But successful examples are few.

The Bank Group lacks a comprehensive, outcome-oriented results framework for guiding and tracking its adaptation efforts. A new system to tally projects with presumed adaptation benefits risks inefficiently emphasizing expenditure at the expense of outcomes.

The Independent Evaluation Group (IEG) recommends revamping the results framework to better track resilience outcomes and promote learning; developing operational guidelines on screening projects for climate risk; investing more in hydrometeorological systems and promoting their use, especially in Sub-Saharan Africa; and devoting more attention to learning how to promote resilient land uses.

Climate adaptation comprises two related challenges: adaptation to current climate variability (ACV) and to future climate change (ACC). Many places are not fully adapted even to current levels of storms, floods, and droughts, which already incorporate past climate change. Closing this adaptation deficit involves actions such as building reservoirs and seawalls, and setting up early warning systems. ACC confronts both an intensification of existing climate variability, and wholly new, transformational phenomena such as sea level rise and glacial loss. ACC can be incremental (“adapt-as-you-go”) or anticipatory—as when decisions need to be cast in concrete today based on expected changes over coming decades.

ACV overlaps with ACC, but not perfectly, as shown in Table 1. “No-regret” ACV provides current benefits while also reducing vulnerability to future changes. Maladaptive ACV, such as unsustainable drawdown of aquifers, helps today but undermines future resilience.

The World Bank Group has extensive experience with efforts to address climate variability, though those efforts have not typically been labeled “adaptation.” New efforts explicitly designated as climate adaptation are largely framed as ACV. The Bank Group and its partners are just beginning to work out when and how to bear costs today to insure against looming future risks.

This evaluation seeks to learn from these experiences by answering questions in three areas:

- **Dealing with climate variability:** What can be learned from past and ongoing efforts to deal with adverse climate, climate variability, and climate extremes? The inquiry centers on disaster risk management, agriculture, and hydrometeorological services.

- **Factoring climate change risks into investment projects:** Under what circumstances is it most important to incorporate climate change risks into the design and appraisal of long-lived investment projects? To what extent, and how, is this being done?
- **Anticipating climate change:** What are the lessons from efforts explicitly aimed at adaptation to climate change at the national and regional levels? What is different about development now that the need for adaptation is better understood?

Table 1. Typology of Adaptation Actions

	Net costs later	Net benefits later
Net costs now	Extreme maladaptation	Anticipatory ACC & “climate-proofing” long-lived infrastructure
Net benefits now	Maladaptation	“No-regret” ACV & Incremental ACC

In addition to this learning-focused agenda, the evaluation asks:

- **How has the Bank Group performed** against climate adaptation goals incorporated in the SFDCC, which was presented to the Development Committee in 2008?

Adaptation at the World Bank Group

The SFDCC ushered in a striking increase in the profile of climate adaptation at the Bank Group over the FY09–11 period. Of 56 Country Assistance or Partnership Strategies approved during this period, 21 had a significant focus on adaptation and 12 had a modest focus; in most cases this was an advance over previous strategies. The Bank Group undertook a number of high-profile analytic activities and helped mobilize funds for the Pilot Program on Climate Resilience,

which aims to integrate resilience into development activities.

Although the Bank Group made progress at the country level, it has not yet put in place an operational system that would identify and mitigate climate risks at the project level. Climate risk screening in both institutions is ad hoc. At the International Finance Corporation (IFC), considerations such as sea level rise and water regime changes were not considered if they did not fall within IFC's investment time horizon, which is 15 years or less for 91 percent of loans. However, IFC has recently mandated life-cycle climate risk screening as part of its revised performance standards.

The Bank Group's new results frameworks for resilience provide inadequate guidance for, or tracking of, improvements in climate adaptation. The results frameworks emphasize inputs rather than outcomes and impacts. Responding to an IDA mandate, World Bank has developed a system for tracking expenditures on activities with presumed adaptation co-benefits. (A similar system is under development at IFC). While potentially useful for tracking attention to climate, it is important not to misinterpret "total spending on adaptation-related projects" as a measure of adaptation effort. For that purpose it is unsatisfactory because it highlights expenditure rather than results; mixes incommensurable expenditures (policy loans, investment loans, and technical assistance) that are not proportional to effort; fails to assess where there are tradeoffs, and where there are complementarities, with poverty reduction; and ignores the likely adaptive impact of rural roads, female education, urban employment, and other interventions that at first glance seem extraneous to climate.

Lessons from National Adaptation Projects

Projects in Colombia, Kiribati, and the Caribbean—the most mature of a set of national adaptation efforts—have succeeded in building up national or regional capacity for analysis and planning, in two cases over more than a decade. All were hampered at first by spreading resources and capacity too thinly across multiple topics and locations. They discovered that planning and execution need to occur in tandem to maintain political and popular support. Kiribati's experience suggests that it is desirable to place a strong central agency in charge of adaptation coordination.

These countries all face serious long-term climate risks: sea level rise and salinization of water supply, loss of high-altitude wetlands, and the spread of malaria to new regions. Yet all have focused mostly on here-and-now climate problems: today's water contamination, storm threats, and malaria infections. These choices reflect a legitimate perception of a large current adaptation deficit, and motivate attention to past efforts to deal with climate variability.

Lessons from Addressing Climate Variability

In agriculture, attention focuses on *rainfed areas*, especially in the drylands, which face the highest climate variability and have high poverty rates. Here, World Bank support for watershed management and sustainable land and water management has had some success in boosting agricultural yields and incomes, which is presumed to make households more resilient to climate shocks. However, there is little or no project-based evidence of direct biophysical impacts on agricultural resilience. Sequences of drought management projects in Kenya and Ethiopia have succeeded in creating functioning institutions for drought mitigation and relief. In Ethiopia, the Productive Safety Net Project has reduced the duration of food insecurity by 0.9 months for drought-affected households and 1.5 months

for others. Another approach to risk management, index-based insurance, seeks to reduce the cost of insuring against droughts and is of particular relevance to pastoralists and rainfed farming. However, small-scale experiments have mostly not yet led to scale-up. Exceptions include a highly subsidized scheme in India and a Mongolian livestock scheme.

Expansion of *irrigation* is a potentially important avenue of adaptation, via expansion into rainfed areas, and through provision of increased storage where rainfall is becoming more variable. A prime concern is boosting the efficiency and sustainability of irrigation, which accounts for 86 percent of human water consumption. Competition for water will intensify as demand increases and climate change disrupts supply. IEG evaluations have highlighted the difficulties, and limited success, in setting up institutions for efficient and equitable water allocation and for sustainable finance of water systems. However, recent and ongoing projects in China are demonstrating important technical and institutional innovations in tracking and regulating actual water consumption, married to incentives to increase water productivity.

The Bank has innovated in financial products for risk management. Catastrophe Deferred Drawdown Options (Cat DDOs)—in effect, lines of credit for emergencies—have been well received among International Bank for Reconstruction and Development (IBRD) clients but are not available to IDA countries, and not appropriate for all borrowers. Financial risk management products, such as the Caribbean Catastrophic Risk Insurance Facility and Malawi weather derivatives—together with financing arrangements for Ethiopia’s Productive Safety Net Program—show how to improve disaster relief financing. However, existing public programs and private markets (including catastrophe bonds) are unable to offer coverage for more than a small fraction of total damages from floods

and storms. This leaves a major gap in climate resilience risk management at the international level.

Sustainability is a key cross-cutting concern if ACV-type projects are to make lasting contributions to ACC. Projects initiated as part of an emergency response effort risk design flaws due to rushed preparation. Physical works including irrigation have failed due to lack of maintenance, especially when funding is not maintained. “Soft” infrastructure, such as mangroves for coastal defense, are vulnerable to natural or human destruction, particularly when incentives for maintenance are missing, as shown by divergent outcomes of two mangrove plantation projects in Bangladesh. Hydrometeorological (hydromet) systems—used to record and analyze data on hydrology and meteorology, such as river flows, precipitation, and temperature—are often financially precarious and unable to maintain equipment, as evidenced by silent or intermittent stations. Institutional effectiveness falters when funding is cut back, as occurred with Kenya’s drought relief program.

Avoiding maladaptation is another challenge. For example, widespread planting of trees poorly suited to local conditions has reduced erosion and boosted carbon storage in China’s Loess Plateau, but has reduced groundwater recharge in water-scarce regions.

Anticipatory Adaptation to Climate Change

In grappling with long-term climate change, it is natural to turn to climate modeling for guidance, and the Bank Group has done so, often innovatively. It has also supported training and capacity building in the use of the models. The models, which are essential for elucidating the global climate system, have been informative in some applications related to agriculture or water development over large regions. But for many planning and design

applications, especially when applied to smaller areas, to precipitation, and to extreme events, models often give too wide a dispersion of readings to provide useful guidance. A review of the application of these models at the Bank Group found that they are often used as a backdrop for urging the adoption of “no-regret” actions, and rarely for quantitative decision making on options.

There are unsolved challenges in incorporating climate change (as opposed to variability) into project design and appraisal. This is a global issue affecting the public and private sector, not just the Bank Group. Lacking guidance on how to do this, project designers may under- or over-invest in climate risk analysis and in exploring options for resilience. Climate change risks are greatest for long-lived, inflexible projects. But changes in precipitation patterns more than 20 years in the future are difficult to predict, and at standard discount rates, those changes may have a muted effect on project economics. IFC has sponsored some cutting-edge analytic studies that provide some insight. They show, for instance, that for the private sector some climate risks are negligible, others essentially unpredictable, and still others addressable incrementally—for example, by raising the Port of Cartagena’s causeway periodically as sea levels rise.

IEG assessed treatments of climate risks in hydropower, a long-lived climate-sensitive sector, and found no consistent approach to climate risk identification. In most projects, climate change risks were not considered if no trend was detected in historic data. One good practice appraisal—for the Trung Son plant in Vietnam—tested the robustness of economic returns to assumed extreme changes in flow, and recommended an increase in safety margin to deal with more severe flood risk.

IEG also assessed practices in the design of protected areas, where the objective of biodiversity conservation has an indefinite

horizon, is not subject to economic discounting, and is threatened in well-understood ways by climate change. Of 34 SFDCC-era projects, eight made some provision for sustaining biodiversity, for instance by seeking habitat connectivity to facilitate temperature-driven migration. However, sustainable funding of protected areas remains a fundamental problem.

Anticipatory adaptation efforts—pay now to avoid damages later—are inherently less appealing to individuals and to countries because of the uncertainty surrounding benefits, and because urgent current needs trump future ones.

This report identified some areas that appear to require anticipatory adaptation. *Basin-level water management* involves irreversible decisions with long-term consequences. To help address this, the Bank has supported transnational basin-level organizations. Progress is slow; it takes decades to build capacity, and to build trust among the partners. The Bank’s experience in supporting the Mekong River Basin Commission illustrates the need for open-source data and models of river basin function, the importance of data sharing, and the inextricability of development and adaptation issues.

Land use planning is potentially critical for many reasons:

- Coastal and floodplain populations will swell by billions this century; shaping exactly how and where they settle could drastically reduce vulnerability to coastal and river flooding.
- Maintaining wetlands, urban parks, and forested hillsides mitigates future flooding.
- Coastal zone management can reduce climate stress on marine resources.
- Anticipated changes in the location of temperature-sensitive crops, such as

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coffee, may require infrastructure or environmental planning.

But zoning-type land use restrictions are extremely hard to implement; only a couple of successful, but small-scale, examples were found. A recently initiated large project that attempts to influence coastal zone development in India will bear watching.

Development of a portfolio of new crop varieties to be ready for emerging pests and climate patterns is a global public good for adaptation. The Bank has supported this goal indirectly through funding of the Consultative Group on International Agricultural Research (CGIAR).

Conservation of agrobiodiversity—especially wild relatives of commercial crops and animals—could be an important input into new crop and animal varieties. The Bank, although a major supporter of protected areas for tropical forests and other biodiversity, has supported only a handful of projects directed at agrobiodiversity.

Directions for the World Bank Group

To a large extent, pursuing climate adaptation starts with the pursuit of sustainable development, especially sustainable agriculture, integrated water resource management, and disaster risk reduction.

One challenge is to integrate ACV—seamlessly and cost-effectively—into sustainable development in a way that also contributes to long-term adaptation (and thus avoids maladaptation). This means designing interventions with a clear logic of how they will promote resilience and poverty reduction, and then tracking results, with course corrections if warranted. Technical advances make this feasible and offer the possibility of immediate benefits in effectiveness, as illustrated by the Sujala project in Karnataka, India. Institutional development is likely to be a strong component of no-regret ACV.

A second challenge is to identify and support anticipatory ACC. Anticipatory adaptation efforts—pay now to avoid damages later—are inherently less appealing to individuals and to countries than ACV because of the uncertainty surrounding benefits, and because urgent current needs trump future ones. But in some cases, failure to take action now closes future options, heightening vulnerability.

IEG makes five recommendations that are intended to focus the institution and its development partners on climate adaptation results.

Recommendation 1: Develop reference guidelines for incorporating climate risk management into project and program design, appraisal, and implementation.

These guidelines are not meant to be rigidly prescriptive but rather to provide guidance on appropriate levels of due diligence for activities of different size, flexibility and longevity, recognizing operational differences between World Bank Group institutions. The guidelines, tailored to project types or sectors, would include relevant risks to be assessed; guidance on available risk assessment tools including their strengths, limitations, and applicability; and options for integrating climate risk considerations into design and implementation. The World Bank Group could use its convening power to assemble climate scientists and industry experts to draft these guidelines, creating a network that would deepen and refine the guidelines over time and might help disseminate them to other interested groups.

Recommendation 2: Develop and pilot territorial and national-level measures of adaptation-related outcomes and impacts for inclusion in an improved results framework. To track progress, the Bank Group should mobilize resources and collaborate with national and international partners to create and test practical, sensitive,

and specific indicators that capture the following dimensions of vulnerability, resilience, and adaptive capacity:

- *Institutional measures of adaptive capacity*—including the status of hydromet systems, disaster relief management systems, and agricultural extension systems; and the geographical coverage of vulnerability assessments.
- *Household measures of vulnerability and exposure*: based on household surveys that combine information on exposure to climate and other shocks with measures of consumption or food insecurity.
- *Biophysical measures of vulnerability and resilience*: such as measures of water use sustainability and of recurrent urban flooding. This could be an area for South-South cooperation, given increasing expertise of developing countries in satellite-based remote sensing of the environment.

Baselines should be established for these indicators, which are intended for ongoing monitoring. These indicators should be refined and improved over time as knowledge of adaptation deepens.

Recommendation 3: Pilot approaches to better assess the costs, benefits, sustainability, and impact of activities with presumed resilience benefits. As sponsor of billions of dollars of activities related to adaptation, the Bank Group is in a unique position to pool knowledge to increase its own and clients' effectiveness in pursuing climate goals. Box 1 lists, as examples, some issues where rapidly shared feedback could directly improve effectiveness in pursuing adaptation and development goals. The Bank Group could develop this knowledge in part by piloting approaches to integrate impact evaluation into selected projects with potential adaptation benefits. Experience in the human development sector shows that an offer of funding for impact evaluations finds takers and generates useful knowledge. To be most effective,

monitoring protocols should be integrated with the project cycle from the start and should include provisions for comparison or control groups. Rigorous *ex ante* assessment, along with attention to intermediate outputs, should be used for activities whose impacts are not readily observable in the near term, such as those aimed at reducing vulnerabilities to long-term climate change or to low-probability catastrophic events.

Recommendation 4: Support countries to improve hydromet services and encourage the use and sharing of hydromet information within and between countries.

Prioritize Sub-Saharan Africa and other low-income countries and regions with poor system coverage and low use of services. Support countries to pilot policy reforms and financing models that promote long-term maintenance and a greater array of hydromet products that are accessible and valuable to end users.

Recommendation 5: Promote attention to anticipatory adaptation to long-run climate change. Specifically,

i) Where coastal zone management, estuaries and deltas, cities exposed to climate risks, regional agricultural development, and national biodiversity strategies are a focus:

a) in the context of country assistance/partnership strategies, signal the need for attention to patterns of spatial development that are resilient to long-run climate change

b) in the context of large-scale projects and programs, include assessment of the feasibility, costs, and benefits of alternative policy instruments for shaping long-run climate-resilient patterns of spatial development

ii) Promote learning on policy instruments for shaping long-run climate-resilient patterns of spatial development, including through small-

scale pilot projects, assessment of ongoing projects, and other analytic activities.

- **Working with partners, explore means of assuring reliable financing of responses to major disasters.**

Box 1. Things We Need to Learn to Promote More Effective and Equitable Adaptation—Some Examples

Poverty reduction, assets, and resilience: As households' incomes improve (from different kinds of projects and policies, in different contexts), to what extent do they become more resilient to climate shocks?

Sustainable land and water management projects: what is their impact, under different conditions, on groundwater recharge, agricultural yields, and carbon storage?

Index-based agricultural insurance: How much does it improve household consumption and resilience?

Ecosystem-based adaptation: Are these interventions (such as mangroves for coastal protection, wetlands for flood mitigation) sustained? If sustained, do they achieve their adaptation goals?

Land use planning and zoning: Are plans being complied with? What is the impact of alternative enforcement and incentive approaches? What are the costs and benefits of different approaches: information provision, permitting, and incentives?

Costs and benefits of flood control and other disaster prevention efforts: What are the costs and benefits of achieving different levels of protection via different means?

Costs and benefits of improved hydromet systems? What are the costs, who benefits, and by how much?

In addition to these recommendations, IEG suggests attention to the following areas.

- **Continued support for integrated river basin management, especially for large transboundary basins.** Keep in mind that progress may take decades and support the development of open-source hydrological data and models.
- **Support for *in situ* conservation of agrobiodiversity.**

Management Response

Introduction

World Bank Group management welcomes this Independent Evaluation Group (IEG) review of World Bank Group support for Adapting to Climate Change and thanks IEG's staff for the close and constructive dialogue with management and staff during its preparation. Given the heightened attention to climate-resilient development, this evaluation will contribute to the World Bank Group's efforts to work more effectively to deliver services demanded by its clients to address the impacts from climate change to development.

Management provided detailed comments to IEG on the first draft and it is pleased to see that most of its suggestions were incorporated in the final draft. The first section sets out comments from World Bank management. The second section provides International Finance Corporation (IFC) management comments. The Management Action Record is attached as Annex 1.

World Bank Management Comments

Climate variability and change pose risks to hard earned development gains of many partner countries, but also provide opportunities to move towards climate-resilient development. The Bank's approach has been to generate the needed knowledge, seek funding, and help partner countries pilot new approaches to incorporate climate resiliency into policies and programs that deliver results on the ground.

Over the last few years, the Bank has accelerated its work on climate-resilient development and used a learning-by-doing approach. There has been increased discussion of vulnerability and resilience in many country assistance and partnership strategies as a result of climate change mainstreaming called for in the Strategic Framework for Development and Climate Change (SFDCC) and the International Development Association (IDA)16 requirement. The Bank's climate coding work clearly demonstrates a significant change in commitments to projects and programs incorporating adaptation over fiscal years 2011-12. Moving to action in countries has meant working with partners and across multiple sectors. To achieve this, Bank teams have found it necessary to spend time developing partnerships and coordinating efforts in partner countries where cross-sectoral collaboration is often not the norm. Our work has also shown that results are not as swift as may have been envisaged when the SFDCC was developed. Over the last few years, the Bank has learned valuable lessons to help move from conceptual basis to action on the ground.

Our work has highlighted some challenges that need to be addressed to help partner countries systematically and coherently move towards climate-resilient development. Low-income countries (LICs), in particular, are faced with a large choice of funds that are wholly or partly for adaptation and climate-related disaster risk management. This complex, and often fragmented, landscape in a limited capacity and knowledge arena is a challenge for many LICs. The donor community as a whole needs to help simplify this landscape and the Bank is committed to work with partner countries to improve their knowledge and capacity to navigate through this complex landscape. We need to improve the practical knowledge and tools available to the Bank project teams. We need to internally, and with partner countries, explicitly and systematically, incorporate climate resiliency into all sectors, and across sectors, through all instruments. We need to deepen and strengthen our work

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on country strategies and operations. We need to also extract lessons learned from our ongoing work, use that knowledge to inform the design of new projects and identify gaps and weaknesses. We need to find the necessary resources to address those gaps – including capacity and tools. We need to build on our climate coding work and ensure that our intent is translated into measurable outcomes. These actions will contribute to the global agenda and ensure that risks to development from climate variability and change in partner countries are minimized.

The IEG report provides good insights into the challenges the Bank has faced in addressing adaptation to climate change. The report raises some general issues, such as the close links between adaptation and development, and the difficulty of separating good development from “adaptation.” In many of our partner countries, the challenges for adaptation are similar to the challenges to development and in many cases they are inseparable from each other. The complexity of the factors and the causal relationships involved in adaptation, adaptive capacity, and resiliency noted in the report with the importance of learning to assess and understand these issues is appreciated. We also agree with the report’s conclusion on the need to assess risks differently for long-term investments—such as infrastructure, coastal, and urban planning—versus that for short-term interventions—such as increasing the variety of food crops grown in an area.

The IEG report supports the importance for sustained engagement in climate-resilient development. The report has demonstrated that the Bank’s continued and sustained engagement has led to positive outcomes for climate-resilient development in partner countries. This is an important finding and implies that we should continue to take and/or scale-up programmatic and sustained efforts for climate-resilient development.

While we welcome this report, we consider that this evaluation may come too early. Much of the Bank’s work on climate-resilient development—especially that supported by the Pilot Program for Climate Resilience (PPCR) and other Bank-managed trust funded work (e.g. Global Facility for Disaster Risk Reduction and Recovery – GFDRR and the Maldives and Bangladesh multi-donor trust funds) is at an early stage of planning or implementation. The value of the IEG report as a resource for task teams and as a knowledge product would have been greater had IEG been able to incorporate the lessons from this much broader body of work.

Specific recommendations. Bank management is in broad agreement with IEG’s recommendations for the Bank. Management concurs with the findings of the report that a systematic approach or guidance on how to incorporate climate risks at the strategic/program/project levels is needed. Given the challenges and needs we have identified, the implementation of this goal will help management take a systematic approach in incorporating climate resilience into our work. In developing guidelines, management will build on ongoing work in the water and energy sectors, social development, in the Regions (such as the flagship report on climate change and infrastructure in Africa, on Climate Adaptation in Arab Countries in the Middle East and North Africa), and the various tools available through the Climate Change Knowledge Portal (CCKP). Our existing approach includes guidelines and tools applicable at various levels—e.g., area, project, and sector. In expanding this approach, management will also draw on the financing and technical expertise and tools available for use by task teams. As part of the IDA16 work program, “screening tools” for incorporating climate resilience into country assistance/partnership strategies and projects are being developed. However, the Bank’s work to date has shown that it is not just the lack of guidelines for task teams that is a major obstacle to systematic consideration of climate change adaptation options, but the way these tools and knowledge are made available and how specific they

are. The Bank will thus draw on the lessons learned from the various Expert Teams—Water, Disaster Risk Management, and Adaptation—to explore effective processes to provide the necessary expertise and assistance as strategies and projects move from concept/design to implementation. Such processes could include increasing the scope of the expert teams and more systematic use of south-south knowledge sharing to help get the right expertise at the right time to project teams on the ground. Management recognizes that the work will require additional financial resources and expertise; efforts will be made to mobilize these. To bring best knowledge and expertise into operations, the Bank will also explore partnerships with leading international institutions.

Management also accepts the need for indicators that can measure improvement in resiliency through pilots that focus on changes at institutional and household levels, and in biophysical characteristics of an area, community, or country. Working with the new World Development Report (WDR) on Risk and Uncertainty, the Bank will develop methodologies and processes to capture intermediate and long-term outcomes. However, management will need to carefully consider its commitments in response to this recommendation. There is a clear need to mobilize extra resources to develop needed methodologies, collect the baseline data, and select the pilots to test them.

Management partially accepts the recommendation to pilot approaches to better assess the costs, benefits, sustainability, and impact of activities with presumed resilience benefits. Management recognizes the importance of being able to quantitatively demonstrate both the costs and benefits of adaptation actions. The Bank will build on the Economics of Adaptation work which included a global study and 11 case studies in various partner countries. This work highlighted many methodological issues and data needs involved in assessing the costs and benefits of adaptation. Assuming that funding can be mobilized and partnerships developed to help address these challenges, the Bank will apply the knowledge to specific pilots designed to provide additional learning on costs, benefits, impacts, and sustainability of resilient development activities.

Management agrees that it is important to support countries to improve the quality and use of hydromet services and encourage the sharing of hydromet information within and between countries. There is a clear need to capture the translation of data into information through products and services that can lead to measurable actions to reduce the risks to people and assets. The Bank's focus would therefore be on delivering clear, locally tailored messages to end-users at regional, national, or local levels. Examples could include services that improve decisions for resiliency in the short- and long-term, such as early warning systems for climate related disaster risk management, area planning, provision of services critical for sustaining economic growth (e.g. information for civil aviation or offshore oil production). Management believes that there is a need to explore how existing data (national or global) can be made more accessible and be used more effectively in decision-making. One of the major challenges is to ensure that there is sustained financial support to both generate and use the data and information. This would require exploring various funding models, including budgetary support, public-private partnership, and “open data” initiatives (at the regional or national level) to improve the use of the information at all levels. There is also some international work that has been started to make existing satellite data and short-term forecasts available as a public good to countries that would not have the capacity or the funding to have their own early-warning or forecasting systems. The Bank's initial work would thus include identifying partners and resources and developing the process to cost-effectively and sustainably implement this recommendation in LICs and MICs.

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Finally, management accepts there is the need to promote attention to anticipatory adaptation to long-run climate change and sees that it is applicable to strategies, landscape—or ridge-to-reef—planning, large-scale projects/programs, and investment in long-term infrastructure that is expected to last to 2040-50 (such as energy infrastructure, ports, bridges, and airports). We anticipate many challenges, especially as the work would be multi-sectoral and/or involve multiple levels of government. We thus suggest taking an approach that would promote learning from changes to policy instruments, analytical work, and investments. Partnership and extra resources would be critical in implementing this recommendation and extending it beyond the work that has already been instigated, for example in the water sector and in some countries funded as part of Pilot Program for Climate Resilience (PPCR) activities or other Bank-managed trust funds.

IFC Management Comments

IFC management welcomes IEG's report on “Adapting to Climate Change: Assessing the World Bank Group Experience.” We appreciate that the report recognizes IFC's leadership in developing cutting-edge analytics for understanding climate risks to private sector projects.

Since 2007, IFC has been piloting climate risk and adaptation initiatives that are now part of IFC operations:

IFC's revised and updated Performance Standards (2012) include specific requirements for identification of climate risks and adaptation opportunities in IFC-sponsored projects.

Starting in FY13 adaptation investments (using IFC's climate definitions) are part of IFC's overall climate smart investment goals.

In cooperation with other multilateral development banks (MDBs), IFC is developing a harmonized system for tracking adaptation investments.

Private sector companies, especially smaller ones, often do not have the resources or capacity to produce and integrate climate change related information in their operations. The latter may be facilitated by outputs from the report's first recommendation which calls on the World Bank Group to develop reference guidelines for incorporating climate risk management into project and program design, appraisal, and implementation. However, to be useful, climate change forecasts for private companies and especially smaller firms need to be sector specific, limited to appropriate geographic areas (and thus usually smaller scales than those typical of climate models), and defined for financial (short) time horizons. Even for the World Bank Group, information in this format is often expensive, not readily available, and may require expert interpretation out of reach of many stakeholders (e.g., for small hydro developers projections of changes in run-off and evapo-transpiration, changes in seasonal variability, etc. on a basin level). Elaboration of tools and methods by the World Bank Group and its partners to address these needs, together with simultaneous work with public sector stakeholders to incorporate these concerns into policy, would greatly improve the enabling environment for adaptation.

A specific instance in which the World Bank Group could work with public agencies to enable adaptive measures by smaller private sector entities is in the context of basin-level information for small hydro developers. The assessment correctly points to some inherent uncertainties using multiple global models to forecast the impacts of climate change at a project level, with an even wider range of uncertainty when multiple models are run using several emission scenarios with no

weighting or probabilities assigned to any scenario. The resulting range of possible outcomes is often so wide that few interventions, if only based on model outcomes, may be seen as “correct” strategies. While narrowly correct with respect to the technical difficulties associated with the current status of near-term, localized climate modeling, this neglects the importance of approaching developmental investments with a concern for avoiding potentially catastrophic outcomes—the “long tail” problem. Alternative decision making frameworks such as those generally referred to under the rubric of “robust decision making” may be more appropriate. As reflected in several IFC pilot studies, this approach emphasizes identification of project vulnerabilities and options for adaptation, reducing the importance of up-front forecasts. The use of these and other appropriately risk-averse decision-making frameworks may provide the basis for the elaboration of guidelines that would greatly facilitate decision making under high uncertainty.

IFC supports the report’s broad recommendation for greater collaboration with industry associations and research institutions in devising approaches to climate risk management and adaptive responses. IFC has been collaborating and in dialogue with various industry associations, including the International Hydropower Association, Ports and Harbors Association, insurance organizations; and diverse research institutions, including the Columbia University Earth Institute, National Climate Data Center, National Center for Atmospheric Research, and UK Met Office. Additionally, in the context of its climate risk studies, IFC has collaborated with over 60 national institutions.

ANNEX 1: Management Action Record Matrix

IEG Findings and Conclusions	IEG Recommendations	Acceptance by Management	Management Response
Guidance is lacking on when and how to incorporate climate risks into project design and appraisal. Current procedures are ad hoc.	Develop reference guidelines for incorporating climate risk management into project and program design, appraisal, and implementation.	World Bank: Agree IFC: Agree	World Bank: We have already started work in some sectors and country strategies, with support from Expert teams – such as those in Adaptation, Water, and Disaster Risk Management. We will build on this engagement and explore partnerships to bring the best knowledge into operations and seek to mobilize resources to systematically scale-up and deepen our efforts in International Development Association (IDA) and International Bank for Reconstruction and Development (IBRD) countries. We will work through existing knowledge platforms and learning programs to make the guidelines readily and widely accessible to project teams. IFC: As the report recognizes, IFC has created the Climate Risk Working Group whose task is to develop recommendations on operational inclusion of climate risk and adaptation considerations in investment project appraisal. Along with operational procedures, the group is tasked with defining tools and methodologies for operational use in climate risk and adaptation assessment for a set of pilot sectors and geographies.

ANNEX 1
MANAGEMENT ACTION RECORD MATRIX

IEG Findings and Conclusions	IEG Recommendations	Acceptance by Management	Management Response
Current results frameworks on resilience are not outcome-oriented and risk emphasizing spending over results.	Develop and pilot territorial and national-level measures of adaptation-related outcomes and impacts for inclusion in an improved results framework.	World Bank: Agree	World Bank: Multiple challenges need to be addressed to make progress in implementing this recommendation. These challenges include developing sound methodologies, gathering consistent and comparable baseline data, and developing indicators that cover institutional, household, and biophysical characteristics in pilot projects. Working with the new World Development Report (WDR) on "Risk and Uncertainty," management will develop methodologies and processes to capture intermediate and long-term outcomes. Management will work to mobilize resources in FY13-14 to develop this system and design pilots.
Costs and impacts of presumed adaptation-oriented activities are not well understood.	Pilot approaches to better assess the costs, benefits, sustainability, and impact of activities with presumed resilience benefits.	World Bank: Partially agree	World Bank: The Economics of Adaptation studies highlighted many methodological challenges and data needs that would have to be addressed to implement this recommendation on cost-benefit analysis alone. There will be additional challenges to measure impacts and sustainability. The work under this recommendation is dependent on additional resources and partnerships for developing methodologies and implementing the pilots. Past experience suggests that this work will take time and the implementation of pilots is not likely to start until FY14 and maybe later.

IEG Findings and Conclusions	IEG Recommendations	Acceptance by Management	Management Response
Hydromet systems potentially offer important benefits, but are poorly maintained in many countries especially in Sub-Saharan Africa.	Support countries to improve quality and use of hydromet services and encourage the sharing of hydromet information within and between countries.	World Bank: Agree	World Bank: A lot of the work to implement this recommendation has already started as part of planned activities—mostly within the Pilot Program for Climate Resilience, but also in other IDA and IBRD countries. This work includes South-South knowledge exchange among practitioners and exploration of some “open-data” initiatives to promote sharing access and use of information and data across ministries/organizations in a country, at sub-national level and in water basins. Management will continue such efforts over the next four years as many of our activities move towards implementation. We will also work with international partners that are exploring ways to get necessary information to the end-users using a combination of new-and-old technology platforms (e.g. web-streaming, SMS and local radios). In FY15-16, we will synthesize lessons learned and success in addressing challenges such as effective use of existing information. We will also develop plans for sharing these lessons beyond the countries currently involved and assess how partnerships have helped with effectiveness and service delivery.
Anticipatory actions, including spatial planning, are critical for some aspects of long-run climate change adaptation.	Promote attention to anticipatory adaptation to long-run climate change.	World Bank: Agree	World Bank: Management will continue the work that has been started to support climate-resilient policies, analytics, and investments in IDA and IBRD countries, funded by the Bank and through trust

ANNEX 1
MANAGEMENT ACTION RECORD MATRIX

IEG Findings and Conclusions	IEG Recommendations	Acceptance by Management	Management Response
			<p>funds. Some examples include work in urban/coastal policies and planning activities underpinned by analytical work and in infrastructure investments (e.g. roads, ports, and energy distribution infrastructure). In FY15-16, we will seek to develop partnerships and mobilize funds to expand such approaches to other sectors and policy areas that would improve medium-long term climate-resilient development efforts in targeted partner countries.</p>

Chairperson's Summary: Committee on Development Effectiveness (CODE)

The Committee discussed the third and final volume of a series of assessments of the World Bank Group's engagement on climate change entitled *Adapting to Climate Change: Assessing World Bank Group Experience—Phase III of the World Bank Group and Climate Change* and draft Management Response.

Summary

Members welcomed the evaluation as an important contribution and commended the Independent Evaluation Group (IEG) and management for collaborating in a very constructive manner. The Committee concurred with the evaluation's findings and recommendations and appreciated IEG and management's general convergence of views. A few members noted that the report came too early to incorporate lessons from broader work that is still in the early stages; however, most found the report to be timely, highlighting that the assessment provides a sound understanding of the challenges the World Bank Group is facing in addressing adaptation to climate change. Members supported the Bank scaling-up efforts in climate-resilient development and underscored the need to continue to take stock as the World Bank Group moves forward in this direction.

Members agreed with the need to develop flexible guidelines on incorporating climate risk management, but cautioned that these should not create new conditionalities. Members also agreed on the importance of building a more results-oriented framework that provides guidance to support and enhances the learning process. Members supported piloting approaches to better assess the costs, benefits, sustainability, and impacts of activities. While noting management's partial agreement on this recommendation, members discerned that the recommendations did not call for a traditional cost-benefit analysis, but rather for observing and capturing knowledge/learning from projects to better understand costs/benefits and make more informed decisions. Members questioned if the Bank has the adequate skills, staff, and budget to accomplish its goals. The Committee recognized that while management is looking at creative ways to assist partner countries navigate the complex climate financing landscape—especially low-income countries—the Bank has limited resources and limited capacity and will have to work closely together with other partners to leverage resources. Members appreciated management's comments about the challenges that small states are facing and welcomed the recommendation on prioritizing resilience measures in Sub-Saharan Africa and other low-income countries with poor adaptation systems and other vulnerabilities. Members also called for further integration of the Bank's work on adaptation to climate change and disaster risk management, and for their continued mainstreaming in World Bank Group operations. Members agreed that the International Finance Corporation's (IFC) targeted approach and the creation of the Climate Risk Working Group were positive and forward-looking solutions. Members noted the important role that IFC has in promoting and fostering adaptation measures and systems.

Anna Brandt, Chairperson

1. Context and Approach

Highlights

- ❖ Climate change intensifies long-standing risks (such as floods and droughts) and introduces new ones, making development more expensive.
- ❖ “Climate adaptation” comprises adaptation to current levels of climate variability (ACV) as well as adaptation to climate change (ACC). Many kinds of ACV will contribute also to ACC.
- ❖ This evaluation draws lessons from the World Bank Group’s experience in dealing with both climate variability and with climate change.
- ❖ Some adaptation actions—those dealing with catastrophic events and long-term climate change—are necessarily evaluated long before final outcomes are observed, based on quality of design and of preparatory investments.

1.1 Development takes place on the surface of a turbulent planet, amid storms and heat waves, droughts and floods. As the world inexorably warms, these climatic challenges intensify and new ones arise. This report draws lessons for climate adaptation from the World Bank Group’s experience in addressing climate variability and the more recently recognized challenge of climate change. To set the stage, this chapter reviews the projected impacts of climate change, sets out an understanding of what climate adaptation means, and describes the evaluation approach.

Two Impacts of Climate Change

1.2 The world is warming, as greenhouse gases from energy use, deforestation, and agriculture clog the atmosphere. Climate change manifests itself in two ways. First, *climate variability, including extremes, is increasing*, as floods and storms (for instance) intensify. Second, there are *long-term, transformational changes*, such as sea level rise.

1.3 Climate extremes are getting worse. (Box 1-1). Some trends—such as increases in warm days, heavy rainfall days, and coastal flooding—stand out clearly. Other trends are harder to detect against a background of high variability from year to year—meaning that by the time a change is unambiguously detectable, it will be large.

Box 1-1. Trends and Prospects on Extreme Climatic Events

The Intergovernmental Panel on Climate Change (IPCC) was constructed as a means of reaching authoritative consensus on climate science. A recent IPCC study reviewed evidence on trends and prospects for extreme climate events. Its findings include an assessment of the strength of the evidence.

With regard to past trends, the IPCC found that:

- It is very likely that the number of warm days has increased.
- There is medium confidence that heat waves have increased in many regions.
- It is likely that more regions have experienced increases rather than decreases in the number of heavy precipitation events.
- There is medium confidence that people have contributed to the intensification of extreme precipitation at the global scale.
- There is low confidence^a that there has been an overall increase in cyclone or tornado activity.
- There is low confidence that there has been any change in river flooding, because gauge data are sparse, and climate impacts are obscured by changes due to land use change and dams.
- It is likely that coastal floods have increased as a result of sea level rise.

For the future, IPCC finds that:

- It is very likely that temperature extremes will increase.
- It is likely that heavy precipitation will increase in many areas.
- Average tropical cyclone wind speeds are likely to increase, though the number of cyclones is likely not to increase.^b
- There is medium confidence that droughts will intensify.
- Due to lack of data, there is only low confidence that fluvial (river) floods will increase, but medium confidence that projected increases in precipitation will lead to local flooding, and high confidence that this will locally affect landslides.
- Coastal high water extremes are very likely to increase.
- There is high confidence of increases in glacial lake outburst floods.

Some published literature suggests clearer trends than the IPCC's consensus findings. For instance, the devastating European heat waves of 2003 and 2010 were the hottest in the past 510 years, and heat waves similar to that of 2003 are projected to occur every other year by the end of the century.

Source: IPCC 2012.

Notes: a. A finding of "low confidence" does not mean that the assertion is false, simply that evidence one way or the other is weak.

b. Pielke (2007) reviews estimates of the relation between wind speed and damages. The data suggest that damages go up as something between the fourth and the ninth power of speed. So a small increase in maximum speed could lead to much higher average damages even if the number of cyclones decreases.

1.4 Gradual, long-term changes will have transformational impacts – those that result not just in a worsening of existing conditions, but in a wholly new situation.

Often this occurs as once-extreme events happen more and more frequently. For instance, as the sea level rises, devastating but once-rare storm surges may occur more and more often until a low-lying atoll becomes uninhabitable. Some examples of transformational change include:

- Freshwater supplies that are becoming salinized in coastal regions and on low-lying islands.
- Climatic zones that are shifting uphill and toward the poles, displacing the traditional belts of grain, coffee, and other crops. Already, the trend increase in temperature in many grain-growing areas is large compared to year-to-year variability¹. This is estimated to have depressed maize production in 2008 by 3.8 percent and wheat production by 5.5 percent compared to a hypothetical world in which climate patterns remained as they were in 1980 (Lobell, Schlenker and Costa-Roberts 2011). Farmers will not be able to keep growing current crop varieties in current locations for long.
- Biodiversity-rich ecosystems that will suffer as temperatures rise and migrating species find “escape routes” blocked.
- The disappearance of glaciers and mountain snowpacks that will result in winter floods and summer droughts in the watersheds below.

1.5 Some climate change trends can more easily be projected than others. In general, trends are more easily detectable and predictable for temperature than for precipitation, for large areas rather than small, and for means rather than extremes. In some cases the risks cannot be reckoned, but this is no cause for complacency. For instance, precipitation projections for West Africa vary tremendously. By the end of the century, the areas suitable for millet-growing under the wettest projections are completely different from the suitable areas under the driest projections (Washington and Hawcroft 2012). So West African countries need to be prepared for a wide range of possible futures.

1.6 The scale of the adaptation challenge depends on how vigorously global greenhouse emissions are curbed. While the global community has committed to a goal of restricting average global temperature rise to 2° C, that goal is now considered nearly unattainable (IEA 2011). Life in a world 4° C hotter will be costlier and beset with more uncertainties. The less the climate is stabilized, the greater the need to plan for the possibility of transformational change at the regional and global level.

Adaptation to Climate Variability and Climate Change

1.7 “Climate adaptation,” as understood in international and Bank Group discussions, comprises two overlapping but distinct challenges. First is the age-old challenge of adaptation to climate variability (ACV) – encompassing day-to-day and year-to-year variation in weather patterns. These are experienced as chronic and extreme droughts and floods, heat waves and cold snaps, storms and cyclones.

1.8 Many regions are not fully adapted even to *current* patterns of climate variability (which already incorporates some degree of past climate change). This is evidenced, for instance, by greater mortality from droughts, floods, and storms in developing countries than in developed ones. Closing this *adaptation gap* involves actions such as building drains, reservoirs, sea walls, and river levees; adopting drought-tolerant crops; setting up early warning systems for floods and storms; and ensuring that roads are built and maintained to withstand torrential rain.

1.9 Adaptation is required, in addition, to ongoing and transformational climate changes. ACC can be *incremental*. For instance, weather insurance premiums can be adjusted from year to year to reflect gradual changes in storm or drought risk. Coastal causeways can be raised by 20 centimeters every 20 years to outpace rising seas. Or, ACC can be *anticipatory*. These actions incur costs today in order to reduce future climate vulnerability. For instance, reservoirs may need to be enlarged today to accommodate increased future variability in rainfall. Populations may need to begin immediately to plan for a long-term retreat from low-lying coasts faced with submergence.

1.10 Adaptation to climate variability overlaps with adaptation to climate change – but not perfectly (Table 1.1). Potentially the most attractive actions are those that already provide net benefits under today’s climate patterns but continue to do so under tomorrow’s,² in whatever way those

Table 1.1. Typology of Adaptation Actions

	Net costs later	Net benefits later
Net costs now	Extreme maladaptation	Anticipatory ACC & climate-proofing
Net benefits now	Maladaptive ACV	No-regret ACV & Incremental ACC

patterns unfold. These no-regret³ or robust actions combine ACV with ACC. Such actions, for instance, include strengthening agricultural extension services as this will help farmers deal with today’s droughts and pests while also laying the foundation for rapid response to emerging new conditions. Coastal defenses to protect against today’s storm surges will also be protective in the future, though perhaps not to the same degree. *Maladaptive* ACV, on the other hand, helps today

but worsens future vulnerability. Unsustainable extraction of groundwater is an example. Supporting settlement in increasingly flood-prone areas is another.

1.11 A finding of this report is that most efforts labeled “climate adaptation” are intended as robust ACV, and not as incremental or anticipatory ACC. Thus, the current agenda of climate adaptation has much to learn from longer-standing experience with development projects that grappled with climate variability – even if they were not labeled “climate adaptation” at the time. This motivates chapter 3’s attention to such efforts.

Climate Change Makes Development More Costly and Complex

1.12 The need to adapt makes development more expensive. The Bank’s *Economics of Adaptation to Climate Change* (World Bank 2010c) study estimates global adaptation costs as \$70 billion to \$100 billion per year (see Appendix F1 for a methodological discussion.) Other studies estimate adaptation costs between \$28 billion to \$100 billion per year (World Bank 2009b).

1.13 These costs are hard to reckon because adaptive actions are so closely tied up with development (McGray, Hammill and others 2007), although there are some cases where the distinction between adaptation and development looks straightforward. For instance, the Kiribati Coastal Calculator (Ramsay 2010) can be used to reckon how much taller a seawall has to be to handle the 2040’s storm surges versus those of 2012. The additional cost of building it taller – attributable to sea level rise – is an adaptation expense.

1.14 But more frequently, climate is one of many factors affecting development (Table 1.2). For instance, water stress is exacerbated by climate change in some places, but is generally related to growth in population and inefficient and unregulated use of water for agriculture. Dryland agriculture suffers from irregular rainfall and is increasingly exposed to higher temperatures, but is also hobbled by poor infrastructure and lack of access to markets. In these cases, climate change adds real costs and uncertainties, but adaptive responses must address all the drivers of risk, and there is no easy way to allocate costs between adaptation and development.

1.15 Moreover, interventions seemingly unrelated to climate could have large adaptive benefits. There’s a strong *a priori* case that resilience can be improved by policies that assist labor to migrate from agriculture to higher productivity and less climate-sensitive jobs. Female education could be important in building household resilience. Freer trade policies could smooth out the effects of local weather shocks

on food prices. This theme – the difficulty of distinguishing adaptation from development – pervades the report and complicates the task of defining its scope.

Table 1.2. Illustrative Climate and Non-climate Drivers of Adaptation Challenges

Adaptation challenge	Climate driver	Other drivers
Urban flooding, Jakarta	Sea level rise	Land subsidence due to unsustainable groundwater extraction; inadequate maintenance of storm drains; conversion of fields and wetlands to impermeable surfaces
Inundation, Kiribati	Sea level rise	(none)
Water contamination and water shortage, South Tarawa, Kiribati	Salinization of aquifer due to sea level rise; depletion of aquifer during droughts	Contamination from unregulated land use above aquifer: latrines, pigs, mining
Agricultural water shortage, Mexico, Yemen, North India	Possible decreased precipitation	Subsidized, unsustainable extraction of groundwater
Changes in flooding and drought in the Mekong Delta and Tonle Sap	Sea level rise, precipitation changes	Dams that regulate flow of the Mekong
Uncertainty about profitability of hydropower facilities	Uncertainty about precipitation trends	Uncertainty about competing uses for water, land use change affecting hydrology, power prices
Glacial lake outburst floods, Himalayas and Andes	Snowmass and glacier melt	(none)

Source: IEG

Evaluation Questions

1.16 In short, adaptation to climate change is a new agenda, but one with deep roots in the familiar struggle with climate variability. The World Bank Group is a pioneer in the new agenda, and a longtime participant in older one. This report seeks to draw lessons from both aspects of Bank Group experience. It poses three main questions:

- **Dealing with climate variability:** What can be learned from past and ongoing efforts to deal with adverse climate, climate variability, and climate extremes? The inquiry centers on disaster risk management and agriculture, two fundamentally climate-driven sectors.
- **Factoring climate change risks into investment projects:** Under what circumstances is it most important to incorporate climate change risks into the design and appraisal of long-lived investment projects? To what extent, and how, is this being done?

- **Anticipating climate change:** What are the lessons from efforts explicitly aimed at adaptation to climate change at the national and regional level? How should development practice change, now that the need for adaptation is better understood?

In addition to this learning-focused agenda, the evaluation asks:

- **World Bank Group performance:** How has the Bank Group performed against climate adaptation goals incorporated in the “Strategic Framework for Development and Climate Change” (SFDCC), which was presented to the Development Committee in 2008?

Scope and Structure of Evaluation

1.17 Climate adaptation, because it comprises responses both to current and future climate patterns, touches many sectors and activities. Climate issues are pervasive in agriculture and water management. Moreover, just about anything that affects household wealth, education, or employment could affect the way people react to climate. So a challenge for this evaluation is to focus on issues where the potential for shaping the adaptation agenda is the greatest.

1.18 The evaluation begins by reviewing explicit attention to climate adaptation at the Bank Group. This includes a survey of the inclusion of climate adaptation issues in Country Assistance Strategies or Partnership Strategies (CASs), an analysis of how climate risks are identified and adaptation benefits are tallied in projects, and in-depth case studies of the three longest-running national or regional climate adaptation projects.

1.19 Chapter 3 then discusses lessons from projects and programs that grapple with climate variability (even if not labeled as “adaptation” projects). It focuses on two sectoral and thematic areas most affected by climate variability: agriculture and disaster risk management (DRM). (A third area, water management, cuts across both of these – see Box 1-2) The chapter concludes with a discussion of investments in hydrometeorological (hydromet) systems, which are relevant to both agriculture and DRM.

1.20 Chapter 4 looks at ACC. It starts with the generic issue of how to incorporate climate change risks into the design and appraisal of investment projects. The issue is elucidated through an in-depth examination of recent Bank Group hydropower projects. Hydropower exemplifies these issues because it is a long-lived, climate-sensitive investment; is important to climate mitigation; has a long tradition of

sophisticated hydrological analysis; and was singled out as important in the SFDCC. The chapter continues with a survey of the thin, mostly analytic set of activities that directly address anticipatory ACC. A final chapter synthesizes findings and makes recommendations.

Box 1-2. Where's the Water in this Report?

Water is central to climate change adaptation, and it is pervasive in this report. Water is central to the discussion of climate variability in agriculture, both irrigated and rainfed, and to drought relief (chapter 3). Because irrigation accounts for 86 percent of human water consumption (Doell, Hoffmann-Dobrev and others 2012)), water management in irrigation is on the front lines for dealing with climate shocks to water availability. Much of the discussion of disaster risk management (chapter 3) relates to floods. Hydromet services (chapter 3) are concerned with monitoring water flows and precipitation. Chapter 4 focuses on hydrological issues in hydropower, and chapter 3 discusses water management at the river basin level.

Source: IEG

1.21 These topics cover much of the evaluable adaptation efforts of the Bank Group, but they are not comprehensive of all possible adaptation issues or activities. For instance, there has been relatively little Bank Group effort devoted to the impact of long-term climate change on patterns of infectious disease (though see the discussion of Colombia in chapter 2).

EVALUATION APPROACH

1.22 If climate change is a long-term, slow-acting threat, how can adaptation efforts be evaluated? It is useful to distinguish four kinds of adaptation efforts, with different implications for evaluation:

- Adaptation to *chronic* climate variability: water stress, flooding, and drought that occur every few years or more often.
- Adaptation to *extreme events*: infrequent but severe droughts, floods, heat waves, and storms, that occur every few decades or less often
- Adaptation to *long-term, transformational change*: such as ecosystem loss, changes in agroclimatic regime, and flooding of islands and coasts.
- *Capacity building* for adaptive institutions.

1.23 Projects addressing *chronic* risks might hope to have observable effects within a few years of operation. For instance, an urban drainage project might successfully eliminate annual floods; watershed management projects could boost crop yields within a few years. So evaluation can approach this class of adaptation efforts with

the full arsenal of evaluation techniques, including impact evaluation. In contrast, it could be a long wait to see whether a dam withstands the 500-year flood for which it was designed, or whether a coastal zone management project makes a coral reef more resilient to the sea temperatures of the 2030s. For adaptation to extreme or long-term risks, evaluation has to rely on checking the plausibility of the logical framework and project design, and on checking whether intermediate outcomes have been achieved. For *capacity building*, it is necessary to rely on measures of institutional effectiveness or capability (Table 1.3 summarizes).

PORTFOLIO ANALYSIS

1.24 Given both the conceptual difficulty of distinguishing climate adaptation from development, and the Bank Group's lack of fine-grained categorization of projects and studies, this evaluation does not attempt a comprehensive measure of the Bank Group's adaptation expenditure or effort. It does include the following issue-focused assessments:

- Review of outcomes of selected sustainable land and water management, watershed management, and drought management projects, FY98-FY11 [chapter 3]
- Review of FY08-11 disaster projects; flood project implementation completion reports (ICRs) FY01-FY11 [chapter 3]
- Degree of consideration of climate risks in investment project design in all World Bank investments in FY11 and IFC investments in climate-sensitive sectors FY05-FY11) [chapter 2]
- Hydropower projects appraised FY08-FY11 [chapter 4]
- Biodiversity projects appraised FY09-FY11 [chapter 5]
- Completed national-level explicit adaptation projects [chapter 2]
- Extent of substantive inclusion of climate adaptation in CASs. [chapter 2]

Specific evaluation methodologies are discussed in the respective chapters.

1.25 Country visits were made, in connection with this evaluation, to Barbados, Belize, Cambodia, Colombia, Jamaica, Kenya, Kiribati, Lao People's Democratic Republic (PDR), St. Lucia, South Africa, and Vietnam.

Table 1.3. Typology of Evaluation Approaches to Adaptation Activities

Type of activity	Scope of assessment	Type of assessment	Chapter 2	Chapter 3	Chapter 4
ACV for chronic risks	Outcome and impacts of completed or long-running activities: adaptation "analogs"	Impact assessment and sustainability (longevity); objective-oriented assessment of relevance, efficacy, and efficiency; assessment of robustness of design to climate change		Rainfed agriculture; irrigated agriculture; weather index insurance; disaster risk management	
ACV for extreme events	Project and program design	Quality of climate vulnerability analysis; design relevance and logical framework; appropriateness of use of climate projections; achievement and cost-effectiveness of outputs and intermediate outcomes		Disaster risk management	Incorporation of climate change risks in project design and appraisal of investment projects
ACC	Project and program design				Long-term anticipatory ACC projects
Capacity building for individuals and institutions, information provision, planning	Outputs and intermediate outcomes	For example, has capacity been built and used; is information reliable and is it being appropriately applied; are plans being implemented?	Institutions for planning and implementing long-run climate adaptation at the national and regional level	Extension services for agriculture in a changing climate; drought relief institutions	

Source: IEG.

2. Climate Adaptation at the World Bank Group

Highlights

- ❖ During implementation of the SFDCC, country-level attention to climate change adaptation surged.
- ❖ National-level projects have built adaptation capacity. Projects have been less effective when spread too thinly across many issues, sectors, and locations.
- ❖ National-level support for climate adaptation has strongly emphasized climate variability, with presumed long-term benefits, rather than anticipatory adaptation to climate change.
- ❖ The Bank Group currently lacks systematic screening procedures for climate risk.
- ❖ The Bank Group's climate results framework emphasizes inputs rather than resilience-related outcomes and impacts.

2.1 This section reviews explicit Bank Group attention to climate adaptation at the strategic, country, and project level. At the strategic level, it reviews accomplishments under the “Strategic Framework for Development and Climate Change,” and critically assesses the new results framework put in place to guide future efforts. At the project level, it assesses current practice in screening Bank Group investment projects for climate risk. At the country level, it assesses progress in integrating climate change adaptation into CASs, describes adaptation-related development policy operations, and national-level investment planning under the Pilot Program for Climate Resilience. It concludes with in-depth evaluations of the three longest-running projects devoted exclusively to climate adaptation at the national or regional level: those in the Caribbean, Colombia, and Kiribati. These provide early lessons for a spate of similar projects underway or in planning.

Strategic Attention to Climate Adaptation at the World Bank Group

2.2 The 1992 Framework Convention on Climate Change recognized the need for climate change adaptation, but adaptation had a low profile at the Bank Group for many years. (It must be noted that globally, much more attention was initially devoted to climate mitigation than adaptation.) The first Bank-executed adaptation project was funded by the GEF in 1997 (see page 25). The 2001 Environment Strategy (World Bank 2001) named adaptation a strategic priority. It emphasized reduction of vulnerability to the current climate, and said that the Bank would mobilize a “Vulnerability and Adaptation Fund” to cover vulnerability assessments and methodology development. However, the Global Facility for Disaster Reduction and Recovery (GFDRR), which

CHAPTER 2

ADAPTATION AT THE BANK GROUP

fulfilled some of the functions of the Vulnerability and Adaptation Fund, was not established until 2006.

2.3 Adaptation was recognized in the Bank Group's Clean Energy Investment Framework (2006-08), but achieved a higher profile with the 2008 adoption of the SFDCC (World Bank 2008b), which spanned FY09-11. The SFDCC's objectives were:

- To “effectively support sustainable development and poverty reduction at the national, regional, and local levels, as additional climate risks and climate-related economic opportunities arise” and
- to “use the [World Bank Group's] potential to facilitate global action and interactions by all countries.”

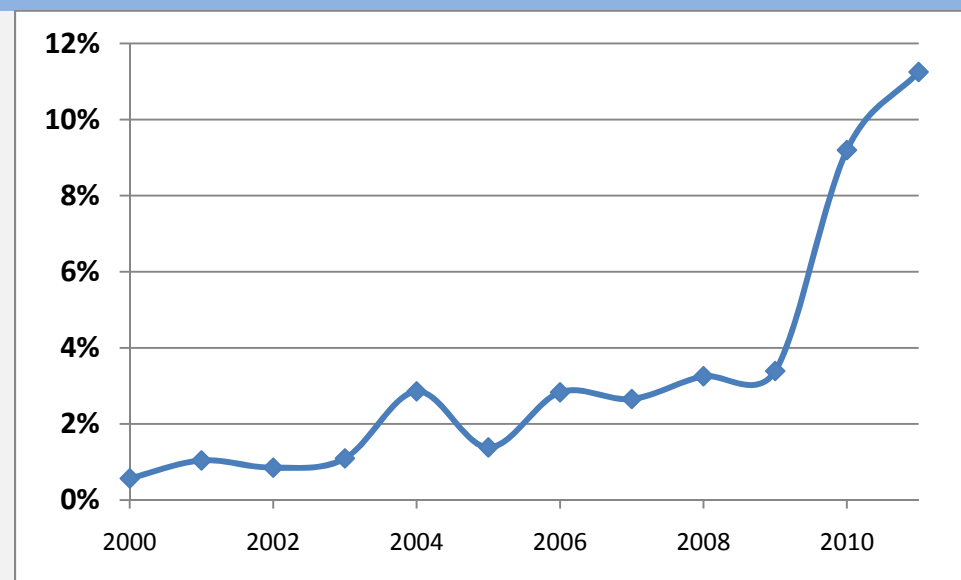
Six lines of action combined adaptation and greenhouse gas mitigation in pursuit of these goals. Specific climate adaptation pledges are shown in Box 2-2. A complete accounting of adaptation-related indicators and an assessment of their fulfillment is in Appendix B.

2.4 Overall, the SFDCC witnessed a striking increase in the profile of climate adaptation at the Bank Group. Accomplishments included:

- A take-off in explicit reference to climate change adaptation in World Bank project documentation⁴ (Figure 2.1)
- Substantial analytic work, including the *World Development Report* (World Bank 2009b) and the *Economics of Adaptation to Climate Change* (World Bank 2010c)
- Increased attention to climate adaptation in CASs (see below) and in sectoral and regional strategies
- Mobilization of funding (in collaboration with regional multilateral development banks) for the Pilot Program on Climate Resilience.

2.5 The SFDCC was less successful in articulating specific strategic directions and operational procedures that would be responsive to country demands while tapping the Bank Group's potential to provide guidance on pursuing this new agenda. Two aspects are discussed below. First, an overall results framework was delivered after the SFDCC closed, rather than midterm as promised. The new results framework has shortcomings described below. Second, neither the World Bank nor IFC has yet developed and applied systematic procedures to screen projects for climate risks.

Figure 2.1. World Bank Projects Mentioning Climate Change Adaptation



Source: IEG.

Monitoring Adaptation Efforts and Results

2.6 The SFDCC promised to develop an “outcome-based results framework” with ‘a set of definitions and outcomes’ in FY09. The document stated that “tracking progress will allow both clients and the World Bank Group to learn more rapidly from what works and what does not and adjust actions accordingly.” (World Bank 2008b). A framework was delivered in FY12, but the sections dealing with climate resilience are not strongly outcome-oriented, instead leaning heavily on inputs: expenditure on projects with “adaptation co-benefits.” This section discusses the pitfalls in using inputs to track results, reflects on the difficulties in measuring climate resilience results, and proposes some solutions.

2.7 Finding comprehensive, sensitive, and practical indicators of adaptation (or resilience) outcomes and impacts remains a challenge. First, as noted in chapter 1, it is not possible to measure effectiveness directly in preparing for long-term climate change or infrequent extreme events. These measures must rely on intermediate outcomes – measures of improvements in information, capacity, and reductions in sensitivity and exposure. Second, adaptation is highly place-specific: the challenges facing Kiribati, Siberia, the Andes, and Kenya are very different. Yet without good indicators, investments in adaptation could be inefficient, pose unexamined tradeoffs against other objectives, or even be maladaptive for long-run climate change (Box 3-3).

2.8 The new results framework does not fully rise to these challenges. Table C1 (Appendix C) assesses proposed indicators against the criteria of relevance, utility, and feasibility. Many of the national-level indicators have low relevance; they are not closely related to measures of capacity or outcomes. Exceptions include measures of policy or institutional preparedness. The project-level indicators tend to focus on inputs or outputs rather than outcomes, are specific to particular adaptation issues, and are sometimes not well-specified. None of the results are disaggregated by gender⁵.

TRACKING PROJECTS WITH CLIMATE ADAPTATION BENEFITS: NEITHER AN INPUT, NOR AN OUTPUT, INDICATOR

2.9 The Bank Group's results framework for climate change will track aggregate spending on activities with adaptation co-benefits, following an International Development Association (IDA) 16 mandate⁶ and elaborating the Rio Markers of the Organization for Economic Cooperation and Development (OECD)-Development Assistance Committee (DAC). While IFC's approach is still under development, the Bank has developed and piloted a system which will be introduced in FY13. This system is *activity-based*. It classifies a project subcomponent as providing adaptation co-benefits "if it reduces the vulnerability of human or natural systems to the impacts of climate change and climate variability related risks by maintaining or increasing adaptive capacity and resilience." Task team leaders are provided with an illustrative typology of activities with potential adaptation co-benefits, but are instructed to tag an activity only if benefits are direct and only "if they explicitly include climate adaptation reasoning and directly address vulnerability or impact from climate variability and change."⁷ In contrast, OECD-DAC's 2009 guidance on tracking is *objectives-based*. It marks the project as having adaptation as a *principal objective* if "the activity would not have been funded but for that objective." Adaptation is recorded as a *significant objective* if the project was "formulated or adjusted to help meet climate concerns" (OECD 2011).

2.10 The Bank's system tracks *spending on activities that include some explicit attention to adaptation benefits*. This provides a potentially useful indication of the extent to which climate change risks, and climate change benefits, are being actively considered in project design. With little additional effort, the tracking system could be enhanced to promote learning about adaptation. As currently designed the system doesn't record which criteria were used to designate the activity as adaptive. If that information were recorded, the system could be used to build up an indexed database of activities with potential adaptation benefits. These activities could then be systematically tracked and compared. For instance, it would be possible to identify and compare the results of particular types of agroforestry or weather index insurance projects.

2.11 However it is important to recognize that tracked financing, using the Bank's system, does not represent *spending on adaptation* and cannot be used as a proxy for

adaptation efforts and results. Here are some possible misinterpretations of tracked adaptation-related spending:⁸

- It does not represent spending that is additional to development expenditure. Marked activities are also counted as development expenditures, and justifiably so, since they include bridges, irrigation systems, sustainable land management and other 'no-regrets' activities.
- It does not represent the marginal cost of climate-proofing an activity or adjusting it to meet climate concerns. For instance, 40 percent of a \$146 million dam improvement project was classified as adaptation-related because bringing the dam up to standards would improve resilience to future climate change. However, consideration of climate risks did not warrant any changes to the project design.
- It is not related to the scale of adaptive effort. For instance, development policy loans are allocated to adaptation based on the proportion of adaptation-related prior actions. But there is no simple relationship between the size of a policy loan and the significance of the prior actions or the outcomes they are associated with. For investment loans, any explicit connection to adaptation is sufficient to mark an entire activity's cost as adaptation-related.
- It does not include activities that have powerful but indirect adaptive benefits, or which are not explicitly flagged as climate-related. For instance, income diversification in rural areas could have powerful resilience benefits. (See Box 2-1.) Similar claims could be made for rural roads (which provide resilience against local climate shocks by facilitating access to a large market) or for female education (Blankespoor, Dasgupta and others 2010) and empowerment (World Bank 2011a).
- It is not suitable for calculating cost-effectiveness. A fundamental issue is that for many activities, development and adaptation are joint products, just as wool and meat are joint products of a sheep ranch. (Again, see Box 2-1.) It would be as incorrect to allocate the entire cost of an adaptation-related activity to adaptation, as it would to allocate the entire cost of the ranch to wool production.
- As research advances, and task team leaders become more familiar with climate change, project documents will be more likely to find and cite linkages to adaptation, and justifiably so. Hence an increase in reported adaptation-related projects over time could reflect growing awareness of adaptation linkages rather than changes in activity mix or content.

In the end, even if it were possible to track actual spending on adaptation, this would represent a focus on inputs, rather than results – an approach not conducive to efficiency and efficacy. Meanwhile, there is a danger that focusing reporting attention on 'taggable' projects – those with direct and obvious relationships to

climate adaptation – could distract from projects with more subtle but powerful benefits.

Box 2-1 Productive grants boosted household income and climate resilience in Nicaragua

The *Atención a Crisis* program in Nicaragua, targeted on a drought-hit region, was a 2005-6 program intended provide an immediate safety net while also promoting poverty reduction and resilience via income diversification. It was set up as an experiment. Households were randomly assigned to a control group or one of three treatment groups. All three received a conditional cash transfer (CCT) (a base amount plus additional funds if children were enrolled in school). The second group received vocational training; the final group received a grant to support productive investments.

Household impacts were measured two years after the program ended. Compared to the control group, the households eligible for productive grants on average had 8 percent higher consumption, enjoying a 15 percent to 20 percent rate of return on the grants. Unlike the control group, the grant-eligible households did not suffer a reduction in consumption if they experienced a drought. Their climate resilience appears to reflect income diversification – these households made a substantial shift towards profitable non-agricultural self-employment. The vocational training group was equally resilient to droughts, but did not experience increased consumption.

The productive grants intervention simultaneously reduced poverty, promoted growth, and increased climate resilience. This experience suggests that there could be important development and resilience benefits from programs that support rural income diversification.

Source: Macours, Premand and Vakis (2012)

TOWARD AN IMPROVED RESULTS FRAMEWORK

2.12 Additional indicators are needed, that are more comprehensive, more precise, and more sensitive to, reductions in vulnerability, and improvements in adaptive capacity. The results framework for the LDCF and SCCF (GEF 2010)– which already applies to Bank projects executed under those funds – contains a wealth of indicators related to these objectives. Many of the indicators are gender disaggregated. Some additional suggested directions are shown in Table C2 (Appendix C). These are more ambitious but more directly focused on vulnerability and resilience, and on additional aspects of capacity. In many cases, the suggestions involve building on Bank Group innovations already underway. They cover the following areas:

- *Measures of household, vulnerability and resilience.* The simplest and most widely applicable measure of vulnerability to climate variation is to track the proportion of households whose consumption and health fall beneath critical thresholds. Resilience could then be measured by comparing the change in this proportion to the shock. This requires panel surveys of households. Biannual surveys conducted

for the Ethiopia Productive Safety Net project are a working example. Suitable data are also being gathered with the assistance of the Bank's Development Research Group in seven African countries, using innovative computer-assisted interviewing techniques to boost speed and accuracy. (The costs of household surveys will decrease as mobile phone-based survey techniques are improved and deployed.) These data need to be complemented by climate information, such as precipitation and soil moisture that is available from remote sensing. Existing early warning systems, such as FEWS NET (Famine Early Warning Systems Network), already use such data and relate it to vulnerability.

- *Measures of institutional capacity.* A well-functioning hydromet system is essential for both ACV and ACC. The number and proportion of reporting stations is a basic, readily available indicator of institutional capacity, although there are additional dimensions of performance, such as service provision. Likewise, agricultural research and extension is essential not just for addressing today's climate variability but also in rapidly responding to future challenges, foreseen and unforeseen. A shift toward the use of information and communications technology (ICT) in extension points the way to effective monitoring. For instance, digitalgreen.org, an extension system in India, provides real-time measures of effectiveness. Disaster risk management systems are another pillar of robust ACV whose institutional capabilities should be tracked. So, too, should be the existence and capabilities of river basin authorities.
- *Measures of water use and depletion.* Water issues are central both to ACV and ACC. Of particular concern is unsustainable consumptive water use. In California, northern India, Mexico, and Yemen, drawdown of aquifers means that the consequences of future droughts will be severe. However, it is becoming increasingly feasible to track water use and depletion using a combination of remote sensing and ground measurements (Rodell, Velicogna and others 2009). World Bank-sponsored projects in China have pioneered in the measurement of agricultural water consumption at a fine scale. Satellite-based measures of gravity can be used to track changes in water storage at the water basin level and are now being applied in ongoing World Bank hydrological studies of Central Asia.
- *Measures of exposure to or resilience to long-term climate change.* Measures here could focus on more anticipatable aspects of long-term change. These could include the proportion of population exposed to a one-meter rise in sea level, and the proportion of protected areas with a specified degree of altitudinal or latitudinal connectivity.

2.13 These are not definitive measures; understanding of climate change adaptation will improve over time. But measures such as these, closely tied to climate and climate impacts, will accelerate the learning process.

Climate Risk Identification for Projects

2.14 The SFDCC committed the Bank Group to “screen climate-sensitive investments with long life spans, starting with hydropower projects and selected water and agriculture projects.” This goal was not accomplished. Following is an account of how the existing risk identification systems deal with climate variability and change.

CLIMATE RISK IDENTIFICATION AT THE WORLD BANK

2.15 In FY11, the World Bank put in place a new comprehensive system (the Operational Risk Assessment Framework, or ORAF) for rating project risks through the entire project cycle. Risks are categorized as stakeholder level, operating environment, implementing agency level, or project level. Project-level risks are further subdivided into design risk, safeguard risk, program and donor risk, delivery quality, and other risk categories. Climate risks do not fit neatly into this system, and are not treated consistently. Sometimes they are characterized as country risks and sometimes as design risks.

2.16 Based on ORAF data, Table 2.1 distinguishes projects in more versus less climate-sensitive sectors, and tallies the number of projects in each group that identified climate risks⁹ or mentions them in the project document. As expected, attention to climate was much greater in the climate-sensitive sectors. A majority of these projects discussed climate, but only a quarter actually identified climate as a risk. There is no presumption, or course, that climate risks should be identified in all projects.

2.17 Of 23 projects that identified climate risks, only one identified a long-term risk due to climate change. This was the Bangladesh Padma Bridge project, in which an expensive asset was constructed that is expected to stand a century or more. Another 16 identified climate variability as a project-level risk, and six mentioned it as a country-level background risk.

Table 2.1. Climate Risk Identification in FY11 World Bank Projects

	More climate-sensitive sector	Less climate-sensitive sector	Total
Total number of FY 11 projects with ORAF documents	78	101	179
Climate risks in ORAF	19	4	23
Climate reference in the project document, no climate risks	40	31	71
No reference to climate in document	19	66	85

Source: IEG

CLIMATE RISK IDENTIFICATION AND SCREENING AT IFC

2.18 While IFC's 2008 Climate Policy articulated an approach to greenhouse gas mitigation, the organization is still in the process of understanding how to approach climate adaptation. It recognizes two avenues. First, to support the transfer of adaptation-related technologies to client countries. Second, to identify risks to its own portfolio and more generally, to the private sector in the developing world, and devise mitigation strategies. An important step in this direction has been the formal adoption (January 2012) of a Performance Standard related to climate: "The risks and impacts identification process will consider the emissions of greenhouse gases, the relevant risks associated with a changing climate, and the adaptation opportunities." The accompanying Guidance Note asks clients to perform climate risk identification for projects located in climate-sensitive areas. (A working group is devising implementation procedures.) The Bank has no equivalent requirement.

2.19 IFC has sponsored an insightful analytic program on understanding climate risks to projects (Stenek, Connell and others 2011a). Recognizing that little is known about the magnitude of risks or the options for mitigating them, IFC assessed those risks for five projects, four of them already active and one under appraisal¹⁰. Some risks turned out to be imponderable but possibly large (such as at a hydropower plant in Nepal); others were small (such as the loss of efficiency in palm oil processing due to temperature rise in Ghana). A particularly interesting case is the Port of Cartagena. The main climate risk it faces is sea level rise, which will eventually submerge the causeway that carries all the port's cargo. Analysis showed that the optimal adaptation strategy would be to raise the causeway by 20 centimeters every 10 years, starting in 2030. Even at a 3 percent discount rate it would not make sense to raise the causeway prematurely. These analyses illustrate how sector- and location-specific climate risks are.

IFC'S APPROACH TO CLIMATE RISK MANAGEMENT IN CURRENT PRACTICE

2.20 To assess climate risk management at IFC, IEG interviewed staff and reviewed documentation for recent projects in three highly climate-sensitive sectors: agribusiness, hydropower, and coastal resorts. (Hydropower is discussed at greater length on page 73.)

2.21 Pending the implementation of the new Performance Standard, climate risk assessment at IFC is subsumed into the conventional areas of risk management: credit, financial, and operational risks. Climate risks often take the form of flood and storm risks to facilities and to business disruption, and are covered by insurance.

2.22 In project appraisal, IFC has until now tested for climate sensitivity during the period of its financial investment, which is less than the operational life of the project. IFC tests the effects of climate shocks on the project's returns (part of its development

outcome) and on the ability of the borrower to service the debt (part of IFC's investment return). It does not consider impacts beyond this period, which is 10 years or less for 58 percent of infrastructure projects, and 15 or less for 91 percent.¹¹ For instance, the appraisal of an investment in a large shipping canal, which uses prodigious quantities of freshwater to operate its locks, dismissed consideration of climate change impacts as being beyond the loan period. Similarly, IFC invested in two coastal resorts on low-lying islands. In both cases, climate change risk was noted in the industry specialists' reports but was not considered in the final project design. (However, at least one of the hotels invested in desalination to avoid putting pressure on the island's scarce freshwater supply.) Of the 22 agribusiness investments made between FY05 and FY11, 10 identified climate- or weather-related risks during appraisal either as a climate risk, agricultural risk, irrigation risk, or commodity price risk. Appraisal documents often note pre-existing mitigation against these risks, including geographic and product diversification.

2.23 In sum, climate risk identification at both IFC and the World Bank has been ad hoc and almost entirely devoted to climate variability rather than climate change risks. IFC's revised Performance Standard, however, takes a step forward by requiring risk assessment over the project's entire life-cycle for projects in climate-sensitive areas. IFC has also formed a Climate Risk Working Group to address these issues.

Country-Level Climate Adaptation

COUNTRY ASSISTANCE AND PARTNERSHIP STRATEGIES

2.24 The SFDCC goal of supporting at least 10 country strategies has been exceeded. Of 56 CASs approved over FY09-11, 33 were identified by the Environment sector board as explicitly supporting adaptation or increase climate resilience. IEG analysis of these 33 CASs found that 21 demonstrated a significant focus on climate adaptation actions, while 12 demonstrated modest focus.¹²

2.25 This represents an increase in attention to climate resilience. Of the 33 CASs that contained any reference to climate resilience, 24 demonstrated a significant change in Bank policy relative to previous practice in that country. The remainder continued earlier strategic attention to disaster risk management or adaptation.

2.26 Most strategies promoted climate resilience through analytic work; information products such as vulnerability assessment or identification of adaptation options, capacity building or support for adaptation, water, or disaster plans. Twenty-one strategies supported implementation or execution of actions supporting climate resilience, and most of these were through disaster operations or mainstreaming

adaptation concerns into agriculture or water sector projects. Of actions most clearly focused on adaptation, most are financed by the Pilot Program for Climate Resilience (PPCR), GFDRR, or GEF.

Box 2-2. SFDCC Commitments to Climate Adaptation

- “Screen climate-sensitive investments with long life spans, starting with hydropower projects and selected water and agriculture projects.”
- “Help some of the most vulnerable countries integrate climate risk management in development processes, on demand and with new financing.”
- Support “increasing resilience in agriculture and its linkages with food security, water resources management including support to country-driven, trans-boundary programs, and to coastal areas.”
- Sponsor “ongoing analytic work to improve understanding of the nature and costs of adaptation processes” in order to “aid developing countries, the international community, and the [World Bank Group] to better determine the incremental costs of adaptation measures and use this knowledge for raising additional finance.”
- Mobilize “additional resources for adaptation.”
- “Customize a series of new insurance and reinsurance products for catastrophic and climate-related risks.”
- “Support strengthening technical and policy expertise on development-climate linkages and decision-making capacity at the country level.”

Source: (World Bank 2008a)

2.27 While strategies have focused on climate resilience, this attention has been almost entirely devoted to addressing adaptation deficits (ACV) to current climate variability rather than addressing new risks from future climate change (ACC). Only four strategies supported specific actions that are likely to be related to long-term climate change; the Cameroon strategy planned to support analytic work that would look at the future impact of climate change on hydropower; the Morocco strategy supported analytic work on climate-induced migration; the Yemen strategy supported an investment project in long-term agrobiodiversity; and the Guyana strategy supported protection against coastal flooding and sea-level rise. Even countries such as Bhutan and Kiribati with high vulnerability to long-term climate change focused their strategies on current variability.¹³

2.28 While not every CAS made climate resilience a top priority, it would not be appropriate to seek such an objective. Some countries will be affected much less severely by climate change than others, some have urgent development needs that may take precedence over adaptation, and in some, adaptation needs are being supported by other development partners. Among the countries whose FY09-11 CAS did not support climate resilience, half of the most climate-vulnerable were fragile states.¹⁴

CHAPTER 2

ADAPTATION AT THE BANK GROUP

DEVELOPMENT POLICY OPERATIONS

2.29 Seven development policy operations (DPOs) account for the largest dollar volume of World Bank operations associated with climate adaptation. DPOs provide general budgetary support, outline policy objectives, and are predicated on prior actions. Prior actions and objectives fell into two categories. One consisted of issuance of broad national climate change policies, strategies, or communications to the United Nations Framework Convention on Climate Change (UNFCCC). In Mexico, this extended to some state-level plans. The other set of actions supported robust ACV policies and actions in specific sectors. For instance, both Indonesia and Mexico bolstered regulations for water basin management.

Table 2.2. Development Policy Operations with Climate Adaptation Content

Project name, ID	Country	Approval year	Amount of loan, US\$ million
First Programmatic Development Policy Loan for Sustainable Environmental Management P095205	Brazil	2009	1,300
3rd Sustainable Development DPL P101301	Colombia	2009	450.0
Poverty Reduction Support Credit 8 P111164	Vietnam	2009	350.0
Natural Resource and Environmental Governance DPO P113172	Ghana	2009	6.8
Climate Change DPL P120313	Indonesia	2010	200.0
Environmental Sustainability and Energy Sector DPL-2 P117651	Turkey	2010	700.0
Adapting to Climate Change in Water Sector DPL P120134	Mexico	2010	450.0

Source: IEG.

2.30 There is no necessary proportionality between the size of the DPO and the magnitude of its policy aims, and it is difficult to ascertain the extent to which World Bank engagement catalyzed the adoption or informed the implementation of the prior actions. Loans in Vietnam have in fact been accompanied by a large trust-funded set of analytic operations related to climate. Mexico has been a large recipient of climate DPOs but also has been a global leader in addressing climate issues. In Mexico, the loans do not provide additional resources to line ministries. Overall, many of the climate DPOs coincided with the global financial crisis and were vehicles for providing budgetary support as part of the Bank's crisis response.

PILOT PROGRAM FOR CLIMATE RESILIENCE

2.31 The PPCR supports the development of national or regional investment plans called Strategic Programs for Climate Resilience (SPCRs). Nine freestanding country-level SPCR and two regional-level SPCR (for the Caribbean and the Pacific) have been

endorsed. Projects developed under the SPCRs are executed by the World Bank and other multilateral development banks.

2.32 The SPCRs typically include climate modeling and vulnerability assessment, other technical assistance, capacity building, and physical investments. Many draw on World Bank analytic work, including the Economics of Adaptation to Climate Change (EACC). For the most part, the projects focus on climate variability issues that are expected to intensify as climate change proceeds. However, long-term climate change issues are flagged for Bangladesh (sea level rise), Bolivia (water scarcity), and Nepal (glacial retreat and precipitation decline).

Case Studies: Supporting Adaptation at the National and Regional Level

2.33 In addition to the PPCR, Bank Group support for adaptation at the national and regional level has been through projects supported by the GEF-administered adaptation funds: Strategic Priority for Adaptation (SPA), Least-Developed Countries Fund (LDCF), and Special Climate Change Fund (SCCF)¹⁵. IEG carried out field assessments of the only completed projects (aside from small National Adaptation Programme of Action, or NAPA, preparation grants), which are in the Caribbean, Colombia, and Kiribati. All were supported by the SPA, which required a connection with biodiversity.

CARIBBEAN ADAPTATION PROJECTS

2.34 The Bank has executed a phased series of adaptation projects for the Caribbean. The first project, Caribbean Planning for Adaptation to Global Climate Change Project, or CPACC (1997-2002), was devoted to planning and information; the second, Mainstreaming Adaptation in Climate Change Project, or MACC (2003-2009), was intended to create an enabling environment; and the recently closed Implementation of Adaptation Measures in Coastal Zones Project, or SPACC (2007-2011), focused on implementation. IEG evaluated the first two.¹⁶

Impact on Information

2.35 Investments in climate monitoring systems foundered – literally. Both projects aimed to “enhance generation of sound scientific knowledge and access to information” in order inform public policies, plans, and programs. CPACC’s major information investment was in 18 sea level rise monitoring stations, complementing an existing network. These would serve the very long-term purpose of tracking climate change impacts. In principle they could also have helped improve early warnings of extreme weather events if monitored continuously, but they took only one reading per month. Maintenance was inadequate, and the stations were damaged by storms and ships. By 2005 none were functioning. The follow-on MACC project rehabilitated 11 stations, but

they used technology that the previous project had already been shown to be technically deficient and difficult to maintain, and by 2011 only three were on line. Data were never fully integrated with the existing network or made useful for navigation, coastal zone management, or storm warnings. A separate and smaller initiative, an innovative coral reef monitoring system, was pursued by both projects but was constrained by lack of trained personnel. It failed to be institutionalized and was not able to adequately network with similar programs run by the U.S. National Oceanic and Atmospheric Administration (NOAA).

2.36 The projects also invested in downscaled climate models, commissioned by the Caribbean Community Climate Change Centre (CCCCC) and undertaken by the University of the West Indies. The downscaled model was based on a single global change model (GCM), which raises questions about its reliability (see chapter 4). Modeling work has built local awareness about climate change and contributed to national communications to the UNFCCC. Projections are distributed on the internet. The project has helped build local climate science capacity, and further modeling work is underway. However, the projections do not appear to have provided quantitative guidance for policy or project decisions.

Impact on Capacity and Institutions

2.37 Operating in 12 countries, CPACC built up a network of national coordination units and focal points. Their project participation helped build their experience and credibility and has helped with mainstreaming climate change. MACC also contributed to the growing abilities and reputation of the CCCCC, which has emerged as a widely recognized regional center for climate analysis and policy advice. CCCCC led the effort to develop regional position papers for use in international climate negotiations.

Impact on Public Awareness and Policy

2.38 The projects were designed to raise public awareness of the need to adapt to climate change. The CPACC focused on formulating policy frameworks that would raise the profile of the issue. Ten of the 12 countries prepared issues papers using existing data to develop policy options for dealing with climate risks in key sectors. But these were not fleshed out, and no dissemination took place, due to budget shortfalls.¹⁷

2.39 The MACC built on this, supporting the development of national sector strategies and action plans in four countries, a scaling-down of original ambitions for multisectoral planning. Project-sponsored water strategies in Jamaica and the Bahamas have led to policy and staff emphasis on adaptation in the Integrated Water Resources Authority. There has been some uptake of water policy recommendations in Jamaica. In

contrast, a project-sponsored tourism plan for Barbados had little influence on the country's new tourism strategy.

2.40 In retrospect, the projects were overly complex in geographical scope and thematic breadth, with inherently difficult coordination problems. A more focused approach might have yielded more rapid progress.

COLOMBIA

2.41 The \$5.4 million GEF-funded Colombia Integrated National Adaptation Project (INAP) ran from 2006 to 2011. Its development objective was "to support Colombia's efforts to define and implement specific pilot adaptation measures and policy options to meet the anticipated impacts from climate change." It had four disparate components, reflecting Colombia's diverse geography and challenges:¹⁸

- *Capacity building for IDEAM, the national environmental, hydrological, and meteorological agency.* This included staff training, upgrading of 157 weather stations, and development of downscaled climate projections.
- *Adaptation in high mountain ecosystems, particularly the páramos.* These high-altitude moorlands strip moisture from fog, providing water to farms and cities (including Bogota) in watersheds below. The *páramos* also contain distinctive biodiversity. The moorlands are threatened by climate change. Warmer weather could shift the cloud belt above the top of the mountains, destroying the moorland ecosystem. But some *páramos* face an immediate threat of conversion to potato farms and ranches. The implicit logic of the component was to reduce this current pressure on the Chingaza *páramo* in order to improve the *páramo's* resilience to climate change and protect Bogota's water supply. It would do this by introducing more profitable, resilient, and sustainable farming systems.
- *Adaptation in coastal and island areas.* The project aimed to reduce current stress on coral reefs to increase their resilience to higher sea temperatures in the future. It included assorted small-scale projects and studies intended to protect the environment and improve the quality of life on the islands, which face water scarcity.
- *Adaptation to "increased exposure to tropical vector-borne diseases (malaria and dengue) induced by climate change."* A warmer, wetter climate could increase the geographical range of these diseases. The project aimed to introduce an integrated dengue and malaria surveillance and control system, which would provide advance warning of outbreaks and result in a 30 percent reduction in infections in 24 pilot areas.

Impact on Capacity and Information

2.42 The capacity building portions of the project were successful. IDEAM trained and retained skilled staff. The weather stations were upgraded, and the accuracy of medium range weather forecasts improved. This is crucial for Colombia, which recently experienced devastating floods.

2.43 Downscaled, long-run (GCM-based) climate model outputs were not found useful for specific adaptation decisions. These outputs were not used by project activities in locations for which the models were specifically downscaled. However, model outputs were used for context-setting in discussions of climate adaptation and in a national communication to the UNFCCC. Creation and use of the projections helped to integrate Colombian scientists and decision-makers into international networks of climate experts.

2.44 Most other investments in models, studies, and data had mixed results. Modeling of the aquifer in water-scarce San Andres Island was well-executed and provided relevant insight into long-term climate impacts, including sea level rise. Experiments carried out on the light and temperature sensitivity and connectivity effects of marine coral helped develop management techniques to adapt to temperature stress. But research studies on carbon and water cycling in high mountain ecosystems had no policy relevance. In the insular component, small-scale studies of farming, agriculture, population, and beach erosion lacked clear orientation toward climate change, and did not produce documentation of results necessary for learning lessons. The mountain component failed to carry out two planned agricultural studies – a case/control analysis of farm system impacts on income variability, and a demonstration of the financial viability of an agroforestry system. Overall, the project missed opportunities for learning – something that should be essential for a pilot project.

Impact on Implementation of Adaptation Actions

2.45 Activities in the mountain component were not strongly linked to the logic of long-term climate adaptation. Most of Bogota's critical upper watershed is protected by a national park and is not under severe pressure.¹⁹ Moreover, it is not clear that the páramos will survive climate change, even if protected from conversion. In fact, the component worked exclusively with farmers in sub-páramo (lower elevation) areas to promote living fences, spring protection, and small-scale productive projects that might contribute to the resilience of these areas. It also generated detailed agro-ecological zoning maps (EETA) of the Chingaza watershed and worked with the municipalities to encourage the insertion of agro-ecological zoning criteria into municipal land use plans. The EETA was not linked to downscaled models of climate change impact. Progress in

inducing farmers and communities to restore landscapes was weak, calling into question the potential to scale up this activity. However, the project was successful in building social capital in the supported watershed.

2.46 The island activities included establishing and marking marine protected areas and creating protection and vigilance plans. The plans appear well designed. Implementation was taken up by a subsequent project.

2.47 The health component was oriented toward predicting season-ahead disease incidence to guide current control activities. Research under the component found that dengue prevalence is much more strongly linked to water management than to climate. The attempt to develop a model for dengue was abandoned and focused instead on providing more reliable water supply and reducing the need to store water. The malaria model is still under development. No concrete action was taken to promote institutional change in the municipalities. The program did not become operational, although work continues to further develop the malaria model, and the project succeeded in building links between the health agency and IDEAM. An unrealistic goal of reducing disease incidence was not addressed.

2.48 While initially oriented to addressing long-term climate change, the project ended up focusing on activities related to climate variability. Colombia is highly vulnerable to current climate conditions, and activities such as early warning systems, malaria control, and improved water supplies on islands have benefits under both current and future climates. Boosting institutional capacities to address current challenges will help prepare Colombia for the future. In the area of health, for instance, the recent increase in malaria and dengue prevalence has been attributed to climate change but may be more related to the aftermath of health system decentralization. An improved health system will be better able to confront the challenge of climate-driven spread of malaria into previously untouched regions.

KIRIBATI

2.49 Remote Kiribati exemplifies climate change concerns. Sea level rise poses an existential threat to the country. By 2070, storm surges of up to a meter could imperil these low-lying atolls, but before that the rising sea will inexorably salinize the country's thin lenses of groundwater. Meanwhile, Kiribati faces severe immediate development challenges. Half the population lives on 32 low atolls, scattered across 3.5 million square kilometers of ocean, with difficult access to services and economic opportunities. The other half is crowded onto South Tarawa, a small stretch of islets. There, population growth, a trouble-plagued water distribution system further stressed by chronic droughts, and poor sanitation imperil water quality and quantity, contributing to high infant and child mortality from diarrhea and dysentery.

2.50 The Bank's involvement with adaptation in Kiribati dates to the late 1990s. A landmark Regional Economic Report for the Pacific Islands was one of the first Bank activities to highlight climate adaptation needs, and pointed to Kiribati's extreme vulnerability. In 2003, the Bank and Kiribati embarked on the first phase of the Kiribati Adaptation Project (KAP-I), devoted to consultations and planning. From the start, the program decided to focus on near-term ACV with immediate benefits rather than anticipatory ACC. KAP-II was intended to build capacity and public awareness; support diagnosis of climate-related problems; mainstream adaptation into government policies, programs, and plans; and undertake pilot measures in coastal protection and freshwater management. The newly initiated KAP-III is intended to expand implementation in those two sectors.

2.51 KAP II's original design was unrealistically complex, especially given low levels of technical and managerial capacity, and proved not to have full buy-in by the government. The project consisted of many activities scattered across many islands. Initially, Bank supervision was lax, relying too heavily on an unprepared and understaffed project management unit. The Kiribati government lagged in setting up a unit to oversee the project and did not make an agreed contribution to the overall cost of the mostly grant-financed project. In part this stance reflected a deeply-held Kiribati view that the necessity of adaptation was externally imposed and its costs should be externally borne. There was also tension between spending on visiting international consultants versus building local capacity for the long term, and between spending on planning versus implementation. Project expectations that communities would readily prioritize investments were foreign to a culture built on making decisions by consensus. Disbursements stalled, prompting a restructuring and simplification of the project.

Impacts on Information and Analysis

2.52 KAP II made some important investments in information and analysis. It sponsored a detailed survey of groundwater quantity and sustainable yield, which has catalyzed publication of an annual report on the status of the water reserves. A Coastal Hazard and Risk Diagnosis and Planning (CHRDP) calculator was developed to estimate damage at specific locations from storm surge and waves under future climate change scenarios, as an aid to coastal zone management and asset protection of infrastructure. An unexpectedly important contribution was the development of a glossary of climate change adaptation terms in the local language. This has proven to be indispensable in facilitating discussions with communities.

Impacts on Policy and Mainstreaming

2.53 KAP II succeeded in developing national water resources and sanitation policies and implementation plans and contributed to the Tarawa Water Master Plan. These are

critical to the island's health and welfare. The KAP projects have also established the importance of placing coordination functions with a powerful central agency – the President's Office or the Finance Ministry – rather than with the Environment Ministry. This lesson is likely to be important for other small countries where adaptation funding begins to rival traditional development funding in scale and coordination needs are great. But there is still a distance to go in mainstreaming climate change adaptation. While Kiribati has had a vigorous role in the international arena, government leadership on domestic adaptation issues has sometimes flagged. It is difficult to verify the extent to which climate concerns have been incorporated into ministerial operating plans. KAP II's work on hazard mapping and on coastal reef monitoring have not yet been mainstreamed.

Conclusions

2.54 During the SFDCC, country and regional strategies have significantly elevated attention to climate adaptation. Significant analytic work has been undertaken, and funds have been mobilized for the PPCR. But the Bank Group lacks a comprehensive, outcome-oriented results framework to guide and track actions. Systems for identifying projects with assumed adaptation co-benefits constitute de facto "results" frameworks that focus on inputs and spending rather than results. The Bank Group also lacks operational guidance for identifying and mitigating climate change risks to investment projects, though IFC has signaled its intention to do so.

2.55 Three projects were sufficiently mature to offer operational lessons on promoting adaptation at the national level. These include:

- The importance of long-term engagement. In Kiribati and the Caribbean, progress in building institutions has required a series of three projects.
- The need for focus. Each of the three projects contained an excess of disparate, geographically dispersed activities lacking obvious synergies. This overloaded scarce capacity and complicated management. GEF funding linked to biodiversity motivated the inclusion of components that may not have been the highest priority for adaptation. In the Caribbean, policy progress was initially made by focusing on single-sector rather than multisector issues.
- Suggestions of the importance of assigning climate adaptation coordination functions to a central agency such as the finance ministry or president's office, rather than to the environment ministry.
- The infeasibility of a strict sequence of information, capacity building, planning, and implementation. Popular and political support requires visible, on-the-ground actions; the key is to build in cycles of learning and execution.

CHAPTER 2

ADAPTATION AT THE BANK GROUP

- Attempts to build information systems mainly for ACC – sea level rise monitors and carbon cycling measurements – have faltered or failed to gain constituencies.
- The need to deal with tensions over ownership and responsibility. This was most evident in Kiribati, the country with the lowest capacity. It involves balancing the use of external consultants versus building local capacity; finding ways to make Bank supervision less onerous while maintaining responsible use of funds; and understanding clients' sometime reluctance to pay for projects with adaptation benefits.

2.56 At both the country and project levels, a striking finding is the perceived primacy of ACV. Even Kiribati, faced with a long-term existential threat, prioritized ACV actions with long-term benefits rather than adaptive ACC. This motivates the next chapter, which reviews lessons from Bank Group projects that address climate variability – whether or not the label “adaptation” was invoked.

3. Dealing with Climate Variability

Highlights

- ❖ Improved monitoring of water consumption may help improve irrigation efficiency, boosting current and long-term resilience of water resource management.
- ❖ Some evidence suggests that sustainable land and water management can boost livelihood outcomes.
- ❖ Household-level agricultural index insurance has had limited uptake except where heavily subsidized.
- ❖ Large-scale drought relief and mitigation projects have built institutions and in some cases yielded measureable reductions in drought vulnerability.
- ❖ Bank-supported financial innovations have helped countries deal with immediate post-disaster liquidity needs.
- ❖ ACV projects need to be monitored for sustainability and to ensure against unintended maladaptive impacts.

3.1 People have long dealt with climate variability (Figure 3.1) but in many cases are far from being optimally adapted to it. The World Bank Group has invested in projects that try to close this gap. Although not designated as adaptation projects, they have an established record that offers lessons for today's climate agenda. This chapter looks at two areas that encompass much of this newly relevant experience: agriculture (including drought management) and disaster risk management. It concludes with an assessment of efforts to boost hydromet services, which are important underpinnings for both areas.

Agriculture and Droughts

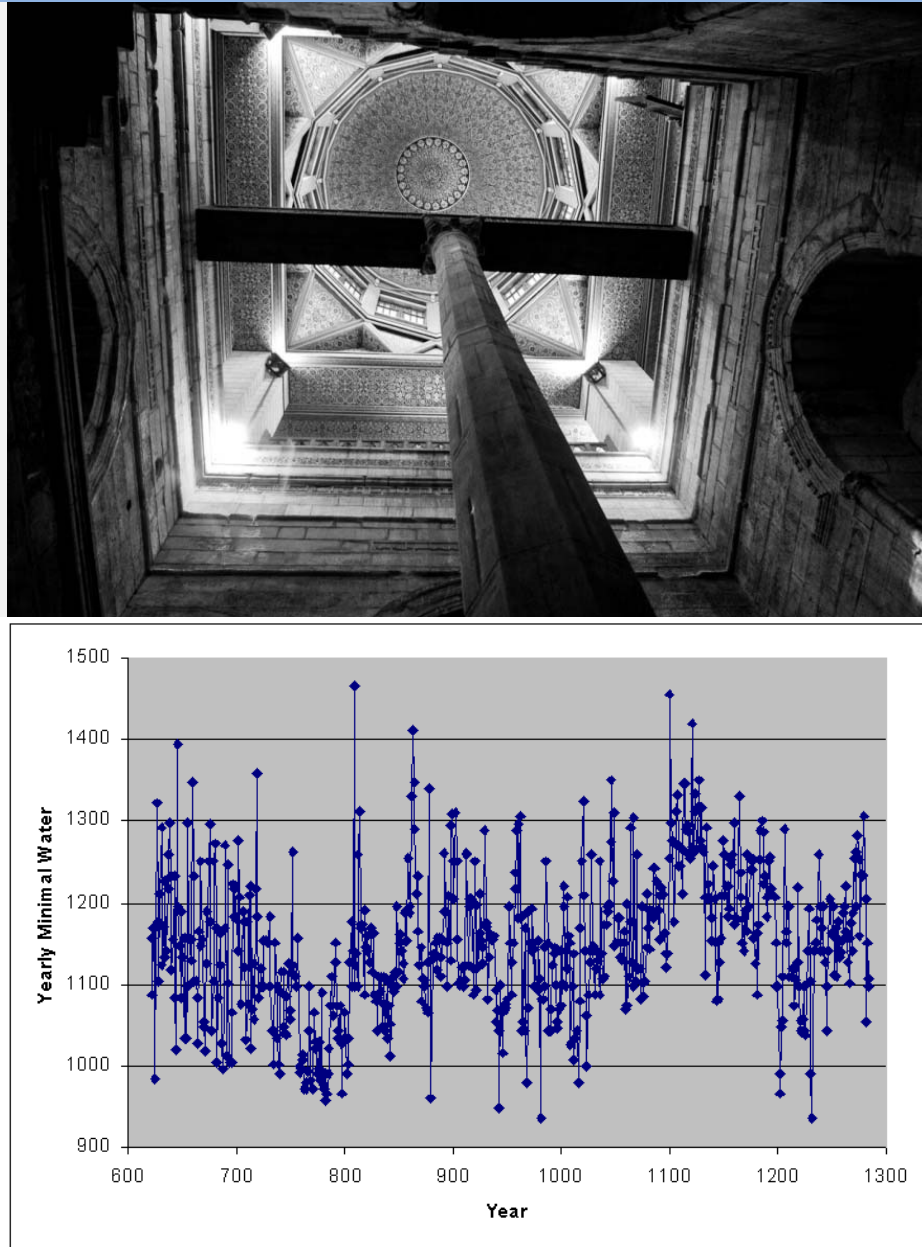
3.2 Climate variability challenges the livelihoods of the 3 billion rural people in the developing world. Sensitivities to current conditions differ by agroclimatic zone and agricultural systems. Rainfed agriculture is sensitive to climate variability – too little or too much rainfall, heat waves, and frosts. This is especially true in the drylands, home to 2 billion people, many of them poor, and many dependent on agriculture. Here rainfall is sparsest, rainfall variability is highest, and drought incidence is high. Climate change is very likely to exacerbate variability in rainfall. Irrigated agriculture – especially large-scale irrigation – is an adaptation response to low or variable rainfall.

CHAPTER 3

CLIMATE VARIABILITY

But it already represents 86 percent of human consumption of water, competing in many places with urban consumption and environmental flows. This competition will get worse as water demand increases and, in many places, will be further stressed by climate change.

Figure 3.1. The Nilometer: Tracking Five Millennia of Hydrological Variability



Source: Hassan (1981); Eltahir and Wang (1999) Photo: K. Chomitz

Note: The column in the picture above is a river gauge: the Nilometer at Roda Island, Cairo, installed in AD 715 and in continuous use until rendered obsolete by the operation of the Aswan dam. Because of the criticality of the Nile floods to farming, nilometers were in use for five millennia, and nearly continuous written records date to the seventh century. An excerpt of the record (lower panel) shows decades-long irregular cycles. Historical data have been shown to be strongly correlated with global climate patterns.

3.3 Climate change will complicate these challenges. It will lead to severe crop yield reductions in some systems while others may see increase in crop yields (Jones and Thornton 2003; Nelson, Rosengrant and others 2009);(Schlenker and Lobell 2010). In many cases, existing coping strategies of these vulnerable populations may not be adequate to cope with the negative impacts of climate-induced, increasingly limited, and highly variable rainfall (CGIAR 2009). In many areas, irrigated and rainfed, rising temperatures will lead to transformational changes requiring adoption of better adapted varieties of plants and animals. Agriculturalists may be able to shift crops, or transition between crops and livestock (Mendelsohn and Dinar 2009), but these transitions may require support in training, extension, infrastructure, and marketing. Potential but poorly understood climate risks – such as failures of monsoon rains, disruption of pollination processes, or emergence of new pests – remain wild cards.

3.4 This section focuses on lessons from dealing with today's climate variability. Because agriculture is a vast topic, already covered in a recent IEG evaluation, the focus here is selective, emphasizing the challenges of rainfed agriculture and of sustainable land and water management. The section looks at experience with national-scale drought mitigation projects. It also assesses experience with index-based agricultural insurance, which features prominently in the SFDCC. Deferred to chapter 4 is a discussion of anticipatory adaptation efforts that involve planning now for transformational change in the future.

IRRIGATED SYSTEMS: IRRIGATION, EFFICIENCY, AND RIVER BASIN MANAGEMENT

3.5 Irrigated agriculture has three important connections with climate adaptation. First, irrigation boosts productivity and protects crops from failure due to heat waves, floods, and droughts. This makes it an important vehicle for adaptation at the local and global scale, by providing a large and reliable supply of food (40 percent of the global total on 20 percent of cultivated land). Second, because irrigated crops are already protected against rainfall variability, they are more sensitive to predicted long-term increases in temperature. Finally, irrigation represents 86 percent of human water use. Water demand already exceeds sustainable supply in many parts of the world, and climate change will add to this stress. More efficient irrigation can help relieve this stress, making water available for residential and industrial use and environmental flows.

3.6 World Bank Group experience with irrigated agriculture was extensively reviewed in two recent IEG evaluations (IEG 2010a; IEG 2010b). Over 1998-2008, the Bank Group committed about \$6.5 billion in irrigation projects, of which \$6.2 billion was from the World Bank. Eighty percent of closed projects were successful in meeting physical goals and 92 percent achieved production goals. However, sustainability was an issue. IEG's evaluation found that while about 60 percent of projects tried to improve

cost recovery, in general they were unable to boost recovery to levels sufficient to cover operation and maintenance, imperiling long-run efficiency and sustainability.

Efficiency in Water Use

3.7 Water efficiency is a key aspect of adaptation in irrigation projects. About half the irrigation projects tried to increase water efficiency, but there was little documentation or measurement of impacts. However, additional information has become available on a set of projects in China²⁰ that place measurement of actual water consumption at the core of a strategy to promote efficient, high-productivity allocation of water.

3.8 Traditional approaches to irrigation efficiency – such as lining the irrigation canals to prevent leakage – can be maladaptive. In many places, water savings are devoted to expanded cropping, so that total water demand stays the same, or even increases. And the apparent water savings often come at the expense of groundwater depletion, since what was leakage to the irrigation operator is recharge from the viewpoint of the well owner.

3.9 The core innovation of the Chinese projects is to use satellite-based measures of crop evapotranspiration (ET) to measure actual water use. ET represents the loss of water by the irrigation system to the atmosphere, as opposed to withdrawals of water, some of which flow back into the canals or into groundwater. The projects set up systems to efficiently allocate water, using ET to monitor farmers' compliance. At the same time, the projects introduced extension services, drip irrigation, and other water and soil management techniques, and alternative, higher value crops, so that farmers can boost incomes while maintaining water use at sustainable levels.

3.10 These projects may provide new approaches to the long-standing, politically challenging problem of promoting efficient and equitable water allocation and use at the level of the local water users' association, watershed, or river basin. These are areas in which the Bank has been active. IEG's water evaluation (IEG 2010b) found that projects with water users' association goals established them only about half the time, but three-quarters of those established were well functioning when the project closed. In contrast, limited evidence from Bank engagement with the creation of river basin organizations suggests that it is easier to establish them than to ensure their sustainability. An ongoing DPO in Mexico, aimed at adaptation in the water sector, tries to highlight the importance of river basin management and bolster the strength and planning activities of river basin councils and organizations.

Box 3-1. Managing Water Resources in the Mekong River Basin

The Mekong River Basin illustrates the challenges of transboundary integrated water resources management and the inextricability of climate change and development planning.

The lower basin riparians – Cambodia, Lao Peoples Democratic Republic, Thailand, and Vietnam – began discussing basin management in 1957 and formed the Mekong River Commission (MRC) in 1995. The MRC’s mission is “To promote and coordinate sustainable management and development of water and related resources for the countries’ mutual benefit and the people’s well-being.” This is a technically and politically challenging task. The lower basin alone has 60 million inhabitants and there are complex interconnections among the many water uses. The river’s annual cycle of ebb and flood sustain the rich fisheries and distinctive ecology of the Tonle Sap Great Lake and regulate water and nutrient flows to the fertile irrigated fields of the Mekong Delta. Development of the basin’s immense hydropower potential can bring income and carbon-free energy, but it also affects water and sediment flows, as well as the river’s unique aquatic biodiversity. Sorting out development plans would be difficult enough within a single country, let alone among four nations with a history of conflict.

The GEF-funded, Bank-executed Water Utilization Project (WUP) addressed both the technical and political challenges. The core idea was to build confidence, trust, and data sharing through the construction of a hydrological model of the basin – the Decision Support Framework (DSF). The DSF would then be used to determine minimum allowable values for water flow and water quality. Agreement on these “rules” would define a “Development Opportunity Space” that could be used to determine the acceptability of proposed plans for development. A similar approach was successfully used, over a long period in the negotiation of European treaties on transboundary air pollution. River basin modeling activities were also included in the Bank-executed portion of the Nile Basin Initiative.

Results to date have been mixed. Progress was made on adopting procedural guidelines, including those related to prior consultation on projects that affect the Mekong mainstream. The DSF was constructed and the process has contributed to capacity building and data-sharing. However, the MRC countries have so far been unable to agree on the critical parameters defining water quality and quantity. So instead of starting with criteria for water quality and quantity and using them to assess development scenarios, the MRC has proceeded in the opposite direction. It has defined some development scenarios and used the DSF to assess their impact on water quality and quantity, together with other environmental and economic impacts.

The DSF has been used to explore the implications of development and climate change for the Basin. In the absence of further development, climate change would tend to increase both high and low flows. However, a development scenario (including ongoing construction of storage reservoirs in China), tends to even out the annual flow cycle, especially upstream in the Lower Basin, counteracting climate impacts during the rainy season and reinforcing them during the dry season. The DSF can assess some of the costs and benefits of these changes, including impacts on the Tonle Sap and on the Mekong Delta, though it does not well represent sediment flows or fish migration.

The Bank is increasingly engaged in analytic and project work on integrated water resource management in large river basins (both national and transboundary), including the Amu Darya, Niger, Shire (Malawi), Tana and Beles (Ethiopia) and Zambezi. As in the case of the Mekong, much of this work relies heavily on hydrological modeling to explore the economic and environmental impacts of alternative development and climate scenarios. A lesson from the WUP is the desirability of using open-source modeling. The WUP uses, in part, a proprietary model. This inhibits wider distribution and independent review of model structure and performance, undermining capacity building and credibility.

Source: IEG mission; (Mekong River Commission 2010)

RAINFED SYSTEMS AND THE DRYLANDS, WITH A FOCUS ON SUB-SAHARAN AFRICA

3.11 About 820 million rural people in the developing world live in the drylands, where moisture stress constrains agriculture and climate sensitivity is severe (World Bank 2007). These areas produce 30 percent of the developing world's agricultural output on 54 percent of its agricultural land. Sub-Saharan Africa and the Middle East and North Africa are further constrained by poor market access, with more than 30 percent of the population further than five hours from a market.²¹

3.12 Regions of current climate sensitivity overlap with places where the environmental and social impacts from climate change would be most severe. These hotspots of vulnerability to climate change are all in rainfed systems and include the mixed arid-semiarid systems in the Sahel, arid-semiarid rangelands in parts of eastern Africa, the coastal regions of eastern Africa, and many of the drier regions of southern Africa (Thornton, Jones and others 2006).

3.13 The World Bank is investing in rainfed agriculture in Sub-Saharan Africa. IEG mapped the locations of active agricultural projects in Africa according to two dimensions that have a strong influence on poverty and on resilience: desert and dryland versus humid regions, and remoteness from markets. (See Appendix H1 for details.) Forty percent of (identifiable) project locations were in desert or dryland areas, as compared to about half of the rural population. Fifteen percent of project locations were in areas that were both dry and remote, compared to 25 percent of the population.

3.14 The productivity of Sub-Saharan agriculture is much below its potential due to inadequate management of land and water in smallholder agriculture (Penning de Vries, Rabbinge and others 1997; Nin-Pratt, Johnson and others 2011). Inadequate management, in turn, reflects institutional constraints on technology delivery, and inadequate market incentives (Nin-Pratt, Johnson and others 2011; World Bank 2008).

3.15 Yield gap reductions are closely tied up with increased resilience. First, better soil and water management practices such as better combination of inorganic and organic fertilizer, crop rotation, and water infiltration techniques would be expected to boost yields while increasing the resilience of cropping to variability in rainfall. Likewise, new technologies such as drought, heat, salt, and flood-tolerant crop varieties, and improved livestock breeds and feeding systems could boost both average yields and resilience. (It is possible, though, that there may be trade-offs.) Higher crop yields and livestock offtake, together with well-functioning markets, result in higher levels of income for farmers and greater demand for farm labor. Farmers with more assets are more likely to be able to withstand price and weather shocks. Such farmers also tend to have more diverse cropping and non-farm activities that correlate positively with higher incomes (Ellis and Freeman 2004)

RESEARCH, EXTENSION, AND SEED DELIVERY

3.16 A well-functioning agricultural research and extension system, including strengthened seed delivery systems (Langyintuo, Mwangi and others 2010), is critical to addressing current yield gaps and adaptation gaps. Such systems are at the intersection of ACV and ACC. As climate changes, these institutions will need to be able detect the direction and nature of change, devise adaptation responses, and disseminate them. Building rural capacity will be an essential part of this (Freeman 2009; Shiferaw, Prasanna and others 2011).

3.17 IEG's agriculture evaluation (IEG 2010b) found that Bank-supported extension services are evolving toward demand-driven approaches and are attempting to link with research and education. In Europe and Central Asia, nearly all extension projects and 83 percent of research activities were rated satisfactory or better. In Sub-Saharan Africa, more than 40 percent of research and extension activities were rated unsatisfactory, reflecting overambitious design and lack of complementary inputs. Few research and extension projects reported on technology adoption. The Digital Green project (digitalgreen.org) provides an example of how modern technology can potentially enhance the effectiveness of extension services while providing useful real-time feedback on which technologies are being adopted by whom.

3.18 An ongoing IFC project in Bangladesh seeks to enhance private sector capabilities to develop and distribute high-yielding, stress tolerant seeds. Monitoring systems are in place to determine the impact on the farmers' income.

WATERSHED MANAGEMENT AND SUSTAINABLE LAND AND WATER MANAGEMENT PROJECTS

3.19 Much resilience-building activity goes under the broad and overlapping rubrics of "watershed management" and "sustainable land and water management" (SLWM). Goals include maintenance of forest; cropland and grazing land productivity; reversal of degradation; mitigation of landslides, floods, erosion, and sedimentation; and maintenance of dry season water flows. Typical interventions include natural or assisted revegetation, construction of terraces, irrigation, or other physical structures for managing water flows, changes in cropping systems, and promotion of conservation tillage. (A newer, related concept, "climate-smart agriculture" holds that activities that improve soil organic content will tend to boost productivity, hold water, and sequester carbon.) Activities labeled "watershed management" are more likely to involve coordinated action at the level of a microcatchment, as opposed to individual farm-level activities. All these interventions would be expected to enhance resilience to climate variability.

3.20 In order to assess Bank experience with this class of activities, IEG identified 22 closed projects with outcome indicators that were largely devoted to watershed management or SLWM. These projects, initiated between 1998 and 2011, spanned both

dryland and non-dryland locations. Appendix A summarizes information on project outcomes, monitoring and evaluation, sustainability, and attention to gender. Of the 20 investment projects for which outcome ratings are available, two were highly satisfactory, eight were satisfactory, and seven were moderately satisfactory.

3.21 Some of these projects had positive payoffs and increased crop yields, affecting the livelihoods of households in the project areas. Where reported, the economic returns to these projects were high, with a median economic rate of return (ERR) of 20 percent and yield increases of 20 percent to 70 percent. However, the quality of monitoring and evaluation varied. Ten projects—likely the better designed and managed—had good monitoring and evaluation systems, with baselines and controls, giving more reliable information on impacts. The Brazil Third Land Management Project promoted a comprehensive set of natural resource management interventions including minimum tillage. It reported increased yields of 30 percent and incomes of 32 percent in participating areas compared to nonparticipating areas. Another project, the Santa Catarina Natural Resources Management and Poverty Reduction Project in Brazil, boosted incomes by 10 percent to 19 percent relative to control groups. The Karnataka project in India had an exemplary monitoring and evaluation system that not only documented project gains, but provided real-time feedback on performance that was used to improve the project during implementation (Box 3-2).

3.22 Most rainfed projects did not provide measures of impacts on soil and water. Several projects used remote sensing to document expansion of ground cover, assumed to correlate with erosion benefits or water flows. The Brazil Third Land Management Project (World Bank 2009a) estimated a reduction in topsoil loss of 50 percent or about 120,000 tons per year. The Loess Plateau project claims to have substantially reduced soil erosion (IEG 2007b), but the project-level monitoring and evaluation (M&E) was inadequate. Two Indian projects reported improvements in groundwater recharge, but measurements lacked adequate controls (IEG 2011a).

3.23 It is important to understand the long-term impacts of these interventions. Box 3-3 explains why an understanding of hydrological impacts is critical to ensure that projects and policies are having the desired effect, and are not in fact maladaptive.

3.24 These projects would be expected to have strong impacts on poverty and on gender, given links between agriculture and poverty and the often dominant role of women in rainfed agriculture. Poverty was an explicit focus of three of these projects, and implicitly in most of the others, which generally targeted poor areas. However, only two projects measured impacts on poverty incidence. Women play a large and distinctive role in SLWM. In this portfolio, seven projects had gender goals or reported gender-related outcomes. These were mostly related to microprojects. A Moroccan project initiated in

1999 (Lakhdar) was not successful in achieving its gender goals. The successful implementation of gender interventions was hindered by lack of a project component devoted to women and existing cultural barriers. Projects focusing on income-generation were not successful because they did not give adequate attention to marketing issues. However, projects in Chad, China, and India reported success involving women in micro-projects, water users' groups, training activities, and village committees.

Box 3-2. The Karnataka Watershed (Sujala) Project

The Karnataka Watershed Management project (FY01-09, \$100.4 million) addressed poverty alleviation in mainly rainfed areas of India by improving the productive potential of degraded watersheds. In addition, it was designed to strengthen the capacity of communities in project districts for participatory involvement in planning and implementation, and in social and environmental management.

The project applied a systems approach, with focus on soil and water conservation and sustainable use, as well as improvement of livelihoods, equity, gender, and community participation. The project included participatory watershed protection and development covering 400,000 hectares.

An important feature of the project was an exemplary monitoring and evaluation system, conducted by the Indian Space Research Organization. The M&E system included a household survey with baseline and control group, and remote sensing monitoring of changes in land cover and cropping patterns. Hydrological measurements were less reliable, since planned equipment was not acquired. Unusually, the M&E system was integrated into project management. IEG's review found that "data from this MIS and evaluation program had a significant impact on improving project implementation. In particular it was instrumental in the decision at the mid-term review to shift funding into providing revolving funds for self-help groups, a move that resulted in a sharper poverty focus for the project and improved opportunities for women and the landless. Similar the data generated enabled operations to achieve better equity among small, medium and large farmers; and greater cost-efficiency in the soil and water conservation works."

The project made a considerable impact on agricultural productivity, with an overall increase in yield up to 19.8 percent. Average income was increased by 24 percent. Cropping was diversified, boosting resilience. Employment increased as a result of project restrictions on using machinery, benefiting the poorest and landless. Consequently outmigration was reduced by 75 percent in the short term. Additional impact was from creating the local institutions, among which the most sustainable were Self-Help Groups, 85 percent of which continued to function even after the project closure. Favorable land use changes were observed, including increased diversification and irrigation. Runoff decreased, suggesting an increase in infiltration and reduction in erosion, and water tables increased, but it was not possible to attribute this solely to the project, since measurements were taken during a period of favorable rains. Unfortunately monitoring has been discontinued so a direct measure of resilience during future droughts is not possible.

Sources: Indian Space Research Organization (2009); IEG 2011a; Sujala staff.

Box 3-3. Trees in the Drylands: Sponges or Vampires?

For centuries, trees have been regarded as sponges that soak up rainy season water and release it during the dry season, nurturing springs and crops. For this reason, reforestation, encouragement of natural regeneration, or prevention of deforestation are often supported as part of sustainable land management efforts.

The reality is more complex, suggesting caution in basing policies and projects on “folk hydrology.” Trees intercept runoff, recharging groundwater. But they also consume groundwater, transpiring it into the air. The net impact on water availability depends on local climate, soils, land use, and topography. An authoritative literature review (Bruijnzeel 2004) found that while reforestation can reduce storm flows, “no well-documented case exists where this has also produced a corresponding increase in low flows.” The review named this issue as an important research priority.

More recent evidence shows the potential for forestation to be maladaptive if the wrong trees are used in the wrong place. South Africa’s Working for Water program increases water supply by *removing* invasive trees. Recent studies indicate that afforestation in the Loess Plateau of China (supported in part by the World Bank) substantially reduced sedimentation and increased carbon storage – but may have significantly depleted water supplies in this semiarid area (Gates, Scanlon and others 2011; Lü, Fu and others 2012).

The Ethiopia Productive Safety Net project (PSNP) restricts grazing in upper watersheds, on the assumption that this will boost water flows to farmers in the valleys below. Hydrological studies suggest that groundwater recharge is, in fact, enhanced by regeneration on hillsides and in gullies (Nyssen, Poesen and others 2008; Descheemaeker, Raes and others 2009; Nyssen, Clymans and others 2010). Regeneration can also provide fodder for the upper watershed dwellers whose grazing opportunities were restricted, but livelihood studies are needed to determine who benefits and who loses from grazing restrictions.

The divergence of experience suggests that it is important to monitor groundwater impacts of projects and programs based on hydrological assumptions. Calder (2005) stresses the importance of doing so with a whole-watershed perspective. Actions that boost water retention and use in upper watersheds may do so at the cost of lower flows to those downhill.

Sources: Bruijnzeel 2004; Chomitz, Buys, and others 2007; Nyssen, Clymans, and others 2010; Calder 2009; Descheemaeker and others 2009; Gates and others 2011; Lu, Fu and others 2012; Nyssen and others 2010.

DROUGHT RELIEF AND MANAGEMENT PROJECTS

3.25 According to EM-DAT data (see Box 3-4 for a caution on data quality), droughts affected 1.9 billion people and killed 11 million during the twentieth century. Over the past 50 years, droughts have been increasing in East Asia and Africa, especially West Africa (Sheffield and Wood 2011). Droughts experienced in childhood can result in malnutrition with lifetime impacts, including depressed earnings (Alderman 2010).

Box 3-4. Shortcomings of Disaster Statistics

The most comprehensive source for disaster data is the Center for Research on the Epidemiology of Disasters' EM-DAT database, but it has incomplete coverage of developing countries, particularly for droughts. Data on the economic impact of disasters is missing for many events, even for many of the most serious disasters. In the EM-DAT database for 1970-2009 damage estimates are missing for about 60 percent of all climate-related disasters, 72 percent of droughts, and for 88 percent of droughts in Africa. It is not the case that missing values are mostly due to minor disasters. For the EM-DAT database's 7,055 climate-related disasters over 1970-2009 that included an estimate for the number of people affected, there is almost no relationship between the existence of a damage estimate and the number of people affected by the disaster (correlation = 0.075). An estimate of drought damages did not exist for any of the 16 droughts in Africa over 1970-2009 that affected more than 5 million people.

The data gaps weaken the credibility of disaster research and analysis that relies on EM-DAT. The lack of data means we should be wary about drawing conclusions from studies that report modest economic damages from drought relative to other disasters (United Nations and World Bank 2010) or modest costs from more severe droughts due to climate change (Mendelsohn and Saher 2011).

Source: IEG analysis.

3.26 IEG identified 13 closed and evaluated drought relief and management projects. Most of these used emergency responses to drought as an entry point for efforts to reduce future drought sensitivity, including Vulnerability Assessment Committees as part of early warning systems, and SLWM.²² The outcome of 10 of the projects was rated moderately satisfactory or better. Five out of seven were rated substantial in efficacy, and seven of eight were rated likely to be sustainable.

3.27 The Bank has had long-term engagements in Ethiopia and Kenya that address drought and food security risks at the national scale through cross-sectoral coordination and which have been subject to detailed assessments (see Appendix D).

3.28 The Ethiopia PSNP is now in its third phase. The starting point had been a reactive system, funded by emergency appeals to donors that used food transfers for drought relief. The system transitioned to a multiyear prefinanced system that set aside contingency funds for years of severe drought. Drought relief took the form of payments for labor on community-identified public works intended to build up resilience to future droughts. These include exclusion of livestock from upper watersheds to promote regeneration of vegetation (Box 3-3). Additional funds were provided as direct support to especially vulnerable households.

3.29 Ongoing studies indicate positive impacts of the project. Impact analyses (Berhane, Hoddinott and others 2011a) found that participants in the public works component of the PSNP experienced 1.5 fewer food-insecure months than nonparticipants in areas not affected by drought.²³ In drought-affected areas, the reduction was 0.93 months. Overall, funding is insufficient to meet defined needs, leading to rationing, despite provisions to set aside reserve funds for severe drought years. Over the long term, population pressure could lead, in some areas, to plots that are too small to be viable.

3.30 In Kenya, the World Bank has funded a sequence of three projects under the Arid Lands Resource Management Project (ALRMP)²⁴ since 1996. These projects have been important in building up drought early warning systems and coordination mechanisms at the district and national levels. Extensive studies by the International Livestock Research Institute (ILRI) (Johnson and Wambile 2011) significant institutional contributions but only weak evidence of impacts on livelihoods and resilience (see Appendix D). Against these institutional successes, a forensic audit by the Bank found that 29 percent of sampled transactions were questionable. The extent of such fiduciary issues – which were generic, rather than peculiarly climate or drought-related – remains a major challenge to addressing persistent food security and reducing livelihood vulnerability in Kenya.

CROP AND LIVESTOCK INSURANCE SCHEMES

3.31 Extreme weather events have a serious impact on the rural poor, particularly on farmers and pastoralists in rainfed areas. In addition to imposing direct losses, climate variability can dissuade farmers from cultivating profitable but risky cash crops and deter lenders from extending credit. The situation of herders is particularly dire, since the loss of their animals destroys their capital; when herd sizes fall below a particular level, pastoralists can fall into a poverty trap (Carter, M. Ikegami and others 2011).

3.32 This provides a strong case for using insurance to shift weather risk away from agricultural households. Carter, Ikegami, and others (2011) find that implied willingness to pay for insurance, among Kenyan herders, would be roughly 170-215 percent of the actuarially fair price, with the highest benefits accruing to those with the smallest herds. Experimental evidence suggests that insurance can induce farmers to switch to riskier but more valuable cash crops (Cole, Giné and others 2011).

3.33 But despite the apparent benefits, agricultural insurance is little used.²⁵ Traditional insurance is not well suited to managing agricultural losses in low-income countries, because the costs of assessing and verifying losses are high relative to the value of assets covered.

3.34 An innovation—index insurance—seems to offer the advantages of insurance at lower cost than traditional approaches. Index insurance bases its payouts on a simple observable measurement, such as cumulative rainfall at a specific rain gauge. This replaces a complex process of loss assessment with a simple bet on rainfall. Variants use remote sensing on crop conditions, or other observations not tied to a specific insured farmer.

3.35 The Bank Group has a 10-year history of supporting pilot programs that provide weather index insurance in developing countries. Most pilots have offered products directly to low income households. But these pilots have struggled with a common set of challenges:

- *High relative costs of operation*, in part because the average value per household of the assets being insured is very low. For example, the average insured value in 2010/11 for India's weather-based crop insurance scheme is roughly \$350 per farmer, and annual premiums are \$29 per farmer (Clarke, Mahul and others 2012). High costs have meant that all index insurance pilots have required a significant degree of subsidization. Even with these subsidies, the upfront premium payments may still be higher than subsistence farmers are willing or able to pay.
- *Basis risk*, meaning that the farmer's actual risk is not well correlated with the trigger for payout—for instance, because rainfall on the farmer's plot differs from that at the gauge, or because farmer income depends on non-weather factors such as pests or price shocks.
- *Farmers' lack of experience with, and trust in, the insurance product*, which may lead farmers to place little value on insurance products (Churchill and Matul 2006; Patt, Suarez and others 2010). A World Bank pilot in Malawi ran a randomized trial where some farmers were offered credit to purchase seeds while others were offered credit bundled with an actuarially fair rainfall insurance product; uptake of the credit alone was 33 percent, while uptake of the bundled package was only 17.6 percent (Gine and Yang 2009).

Table 3.1. Major Agricultural Index Insurance Supported by the Bank Group

<i>Country</i>	<i>Institution</i>	<i>Intervention type</i>	<i>Enrollment</i>	<i>Years</i>
Mongolia	World Bank	Investment, \$18million	7,000 herders as of 2010-11	2006-
India	World Bank, GFDDRR	Technical assistance	9 million farmers in 2010-11	2004-
Malawi	World Bank	Pilot	1,800 farmers, \$80k assets insured	2005-7
Ethiopia	World Bank	Pilot	50 farmers	2005
Kenya	World Bank, IFC	Grants, Premium subsidy	3,000 herders	2008-

CHAPTER 3

CLIMATE VARIABILITY

<i>Country</i>	<i>Institution</i>	<i>Intervention type</i>	<i>Enrollment</i>	<i>Years</i>
Nicaragua	World Bank	Pilot	\$1.5m of assets from medium-large farmers	2008
Thailand	World Bank	Pilot	\$300k assets insured	2007-8
Kenya	World Bank, IFC	Technical assistance	23,500 farmers, 19 agribusiness firms, as of 2011	2009-
West Africa	IFC	Technical assistance	679 farmers	2010-
Rwanda	IFC	Technical assistance	7143 farmers as of 2012	2010-

Source: IEG

Note: This does not include support for feasibility studies or other assistance that have not yet led to products.

3.36 Insurance designers face difficulties in determining which events to cover. Insurance against frequent events – say, the once-in-5-year drought – is inherently expensive. But with insurance that covers only less common events – say, the once-in-10-year event – purchasers may experience many years of premium payments with no observed payout. They may grow disillusioned and distrustful of the insurer. Mistrust will grow if crops fail but payouts are not triggered by the index due to basis risk. Experimental evidence from China supports the idea that future uptake rates are dependent on observing payouts (Cai 2011).

3.37 Though most index insurance pilots have not led to scaling up, two Bank-related index insurance projects are operating at large scale. (See Annex I5 for details.) The Weather Based Crop Insurance Scheme in India is by far the largest in the world; as of 2010-11, over 9 million farmers were enrolled (Clarke, Mahul, and others 2012). The scheme draws its origins from a 2003 pilot in Andhra Pradesh that received World Bank technical assistance. The WBCIS system relies heavily on public subsidies, with premium rates capped at 1.5-2 percent of insured value for wheat and other food crops; over 2007-10 total payouts exceeded total premiums by 30 percent. Participation by farmers is largely compulsory, tied to credit access. Basis risk remains significant; farmers who suffer a total crop loss will still have a 1 in 3 chance of receiving no payment from the WBCIS (Clarke, Mahul, and others 2012). The Index-Based Livestock Insurance Project in Mongolia has been adopted (for winter 2010/11) by 11 percent of herders in target areas. Observed uptake may have been due in part been to three successive years of severe winters and high payouts (including the worst winter ever recorded in 2009/10), which have strained program finances.

3.38 Designers should consider the primary purpose being achieved with agriculture insurance (World Bank 2011e). If the goal is to insure against the macroeconomic consequences of a major weather shock in an agriculture-reliant area, then insurance should target national or regional governments or agribusiness enterprises. If the goal is

to increase lending for farm inputs, then the appropriate intervention might be insurance products that target banks (which bear weather risk, since their loan defaults are higher in years with poor weather). IFC's Global Index Insurance Facility is taking this approach, targeting banks, cooperatives, and other organizations.

3.39 Index insurance at the governmental level may be an effective means of financing social protection programs. An IEG evaluation of social protection mechanisms (IEG 2011b) found that Bank operations supporting social safety nets have been generally successful, particularly in low-income countries, but that many existing programs were not well positioned to respond to systemic crises such as food price shocks by identifying and assisting affected poor households. This suggests that local government could purchase weather insurance and use payouts to finance crisis relief. Safety net payouts could also be made to landless farm laborers – among the most vulnerable rural residents – who may not be reached by direct insurance instruments that only pay farm owners.

3.40 The Bank's support for an ongoing weather derivative instrument in Malawi is an interesting example. The derivative effectively functions as an insurance contract; a premium is paid up front (funded by the United Kingdom's Department for International Development), and then the government of Malawi receives a payout if predicted maize yields fall below a threshold level due to drought. Maize yields are predicted using a crop prediction model based on observed rainfall. The Bank acts as an intermediary between Malawi and reinsurance companies and investment banks. The derivative is tied into a social protection mechanism, whereby payouts will be used by the government to purchase grain internationally in the event of poor domestic harvests, which can then be distributed to drought-affected areas. For low-income countries, such schemes may require ongoing donor support.

CONCLUSIONS: AGRICULTURE AND DROUGHT MITIGATION

3.41 In rainfed agriculture, especially in the drylands, current climate sensitivity is great, and linked to poverty. Project experience has shown that improved soil and water management boosts yield and household incomes, presumably also cushioning rural households against climate and other shocks. Irrigation is a powerful means of boosting incomes; in those areas where climate change brings increased precipitation, this will be an important adaptation opportunity. It is plausible that SLWM practices improve farm resilience against rainfall variability and drought, but there is also a possibility of maladaptation, and hydrological impacts are not being systematically assessed.

3.42 All agriculturalists, but especially rainfed farmers and herders, are subject to weather shocks, including droughts and floods. One line of response has been to build up institutions for drought mitigation and relief. These combine early warning systems

with coordinated responses, including safety net payments in food or cash. They can invest in SLWM or improved markets as means of increasing drought resilience. Engagement over more than a decade in Ethiopia and Kenya has built capacity in these institutions. The Ethiopian program has demonstrably reduced food insecurity among poor and drought-affected households. It also illustrates an approach to proactive planning for drought relief.

3.43 Another approach to rural risk management is to employ new, index-based agricultural insurance techniques. Trialed over the past decade, these are expected to be cheaper and more implementable than traditional insurance products. However, most efforts are small pilots. Schemes that have enjoyed significant uptake rates have mostly required significant subsidies. The products do not cover landless rural labor. Impact assessments on poverty and gender are lacking. While it is too soon to give up on funding household-oriented weather index insurance pilots, alternative including developing products towards banks (in connection with credit risks) or governments (in connection with social protection) – trends that are already underway.

3.44 As water demand grows, and climate makes supply less reliable, increased irrigation efficiency is an important way to ease water stress and promote sustainable water use. But the efficient and equitable allocation of water (at the watershed or basin scale) has been a politically difficult and elusive goal. China has begun to demonstrate a promising new technical approach to water use management, but its replicability elsewhere is uncertain.

3.45 Effective research and extension services will be critical to help agriculturalists adapt to unfamiliar new conditions. It can take decades to build capacity, a time scale consistent with long-term adaptation planning. Challenges in low-capacity countries are high, but there have been some successes.

Disaster Risk Management: Floods and Storms

3.46 Floods and storms already sap development, and will become more burdensome as the climate changes and as people continue to move to disaster-prone coasts and floodplains. Many actions that prepare for today's disasters will also reduce vulnerability for tomorrow's. This chapter reviews lessons from Bank Group experience on preparing for fast-moving climate disasters.

DISASTERS ARE A LARGE AND GROWING DRAG ON DEVELOPMENT

3.47 Our understanding of disaster impacts is limited by poor data quality (Box 3-4). Clearly, though, climate-related disasters hurt. EM-DAT (weaknesses acknowledged) indicates an annual average of 43,000 deaths and \$13.5 billion in damages from climate

disasters²⁶ in developing countries over the period 1970-2011. Over 2001-06, losses in high-income countries were less than 0.1 percent of GDP, losses in low-income countries were roughly 0.3 percent of GDP and losses in middle-income countries were about 1 percent of GDP (IPCC 2012). The most severely affected countries are small island developing states; 12 of the 25 countries with annual losses over 1970-2010 exceeding 1 percent of GDP are small island developing states (United Nations and World Bank 2010). A review of the literature on the impact of natural disasters on economic growth (United Nations and World Bank 2010) finds a lack of consensus on the impact of disasters, once other factors are accounted for. The review finds that, on average, moderate disasters have little impact, but that severe disasters lead to sizeable losses of GDP. A median “severe” drought or flood reduced GDP by roughly 1 percent, with larger proportional losses in poorer countries.

3.48 Disasters are much more likely to affect the most vulnerable members of societies, particularly women and the poor. For example, the urban poor are more vulnerable to disasters because disaster-prone areas tend to have lower property prices, and so tend to be occupied by poor citizens (often in informal settlements). Poor areas often have lower levels of protective infrastructure, and housing is of low quality and is much less likely to withstand a flood or cyclone. The poor are also likely to be less able to cope with a given shock, as they have few assets and often little access to economic or social safety nets. Disasters often have more severe consequences for women, in terms of both mortality and economic impacts. For example, cyclones in Bangladesh have had much higher mortality rates for children under 10 and women over 40 (Bern and others 1993). The 2004 Indian Ocean tsunami may have killed many more women than men (in Indonesian villages surveyed by Oxfam, 77 percent of the deaths were of women (Oxfam 2005). Disasters reduce life expectancy among women more than among men, particularly from the most serious disasters and particularly among the poor (Neumayer and Plümper 2007). The gender gap in primary education widens significantly after major disaster events (UNISDR 2011).

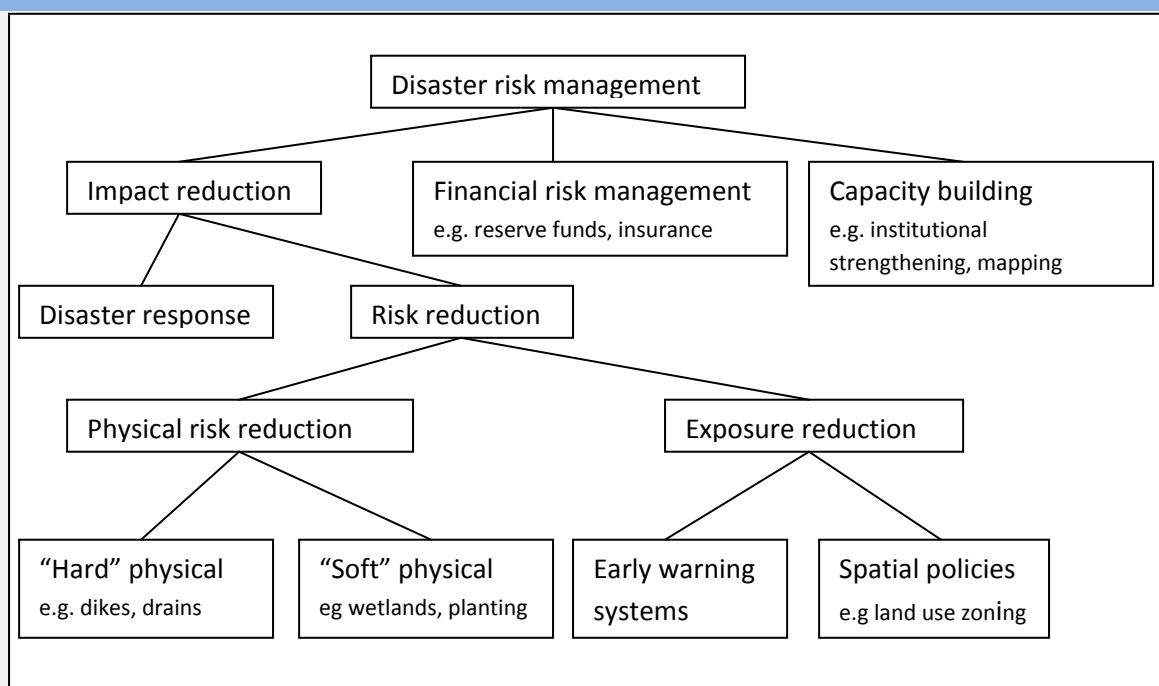
3.49 Many factors other than climate change contribute to disaster risk. Jakarta is a case in point. The city suffers from both chronic flooding every year and extreme floods every few years. The 2007 flood alone covered 25 percent of the city and caused financial losses of \$900 million. Flooding has been blamed on deforestation in the nearby mountains, but the main causes lie closer to home. Wetlands and rice fields have been paved over, in defiance of zoning regulations. Drainage canals are blocked by garbage, the result of an ineffective solid waste disposal system. And while the city confronts sea level rise of 60 centimeters or more over this century, unregulated and unsustainable groundwater extraction has already sunk coastal areas of the city by up to 4.5 meters over the past 50 years. Parts of the city could subside another 5 meters this century if groundwater extraction is not brought under control, and will likely sink a

further 1.5-2 meters even if groundwater use is curtailed by 2020 (World Bank 2011c). But Jakarta's situation is shared by Bangkok and other coastal megacities (World Bank 2010a).

MANAGEMENT OF CURRENT DISASTER RISKS CONTRIBUTES TO CLIMATE ADAPTATION

3.50 Figure 3.2 presents a taxonomy of disaster risk management efforts. Most of the disaster risk management efforts will also promote long-term climate adaptation. First, systems that defend against current storms and floods will be generally helpful in defending against more intense future events. Second, disaster risk management depends heavily on capable institutions that prepare for, detect, and warn about disasters, and manage recoveries after disaster hits. Current support for institutions can help accelerate the maturation of strong institutions to face mid-century challenges. Third, spatial policies offer the promise of reducing exposure to future hazards.

Figure 3.2. Taxonomy of Disaster Risk Management Efforts



Source: IEG.

3.51 However, some actions might help today but be ineffective or maladaptive in the long run. For instance, coast-defending mangrove plantations may not survive sea level rise or salinization. Small dykes that protect lowlands from chronic floods might encourage settlements that would then be threatened by more severe floods.

THE BANK HAS SHIFTED ITS EMPHASIS FROM DISASTER RELIEF TO DISASTER RISK REDUCTION AND MITIGATION

3.52 In the past, the Bank has had a highly reactive stance to disasters. A 2006 evaluation of natural disasters found that while the Bank had demonstrated flexibility and effective coordination in disaster response, the Bank's attitude to disasters had been reactive and tactical, rather than proactive and strategic (IEG 2006b).²⁷

3.53 But there has been a clear shift toward risk reduction in World Bank disaster projects by 2008-10²⁸. Comparison of 90 disaster investment projects over 2008-10 to a set of 528 disaster projects over 1984-2007 shows a significant increase in the number of projects that support risk reduction activities. (See Appendix G2 for methodology.) Projects with hard risk reduction increased from 28 percent to 40 percent and those with some soft risk reduction, exposure reduction, hydromet support, or financial risk management increased from 20 percent to 42 percent – a big increase, but still a minority of projects. There is evidence of significant “mainstreaming” of disaster risk reduction into non-dedicated disaster projects. Mostly this is through drainage and flood protection in water sector projects that focus on water supply and sanitation or through irrigation, drainage, or other works integrated into agriculture and rural development projects. Most exposure reduction and resettlement has been in urban water projects, most warning systems have been for cyclone or flood-related projects, and most financial risk management mechanisms have been safety nets or microinsurance for agriculture or drought-oriented projects.

FLOOD RISK REDUCTION

3.54 The Bank has a long history of involvement in flood control projects. To synthesize the lessons from these projects, IEG reviewed the 16 evaluations (in Project Performance Assessment Reports, or PPARs) of World Bank projects over 1990-2010 that supported flood response, reconstruction or risk reduction (including urban drainage), and the 27 Implementation Completion Report (ICR) Reviews of projects completed between 2001-11 where flood protection was listed as the primary or secondary sector (see Appendix G2). The PPAR projects included 8 with major flood components and 8 with relatively minor flood works. The ICR Reviews covered a large set of projects supporting flood control schemes, large drainage systems, and dams where flood control was a major benefit. Several lessons become apparent from analysis of this history.

3.55 The Bank has generally been effective in supporting traditional public works construction. In most projects, floodbanks and drainage were successfully constructed, and evaluations found that works were successful in reducing flood risk. Of the 27 projects completed, 2 were rated by IEG as having highly satisfactory outcomes, 10 were satisfactory, 10 were moderately satisfactory, 5 were moderately unsatisfactory

and none were unsatisfactory. Even in the cases where institutional or other challenges meant that project objectives were not achieved, the physical construction works were often completed successfully.

3.56 “Soft” risk reduction and exposure reduction measures can be successful when well designed. For example, a series of Water Quality and Control Project implemented in Brazil over 1992-2011 successfully reduced vulnerability to floods in Curitiba and São Paulo through a combination of physical flood control infrastructure and by creating dedicated ribbons of green spaces in the flood banks by the river (World Meteorological Organization and Global Water Partnership 2004).

3.57 Sustainability of flood protection is threatened by poor maintenance. For example, an urban environmental and sanitation project in Ghana constructed a set of storm drains that reduced flood risk in Accra, but an IEG evaluation three years later noted that maintenance had been poor and that the primary five-meter drain had already filled with two meters of silt (IEG 2006a). A coastal embankment project in Bangladesh was generally successful in rehabilitating embankments and introduced a number of new design innovations, but sustainability was thought to be unlikely as sufficient resources for maintenance were not available. In a Belize project, inadequate maintenance and unregulated construction blocked the drains after just four years (Box 3-5).

Box 3-5. Two Half Drains Are Not as Good as One Whole One

A project sought to alleviate chronic flooding in six coastal Belizean towns. Because of macroeconomic constraints on lending, only half the needed funds were available. Rather than scale the project down, the government elected to spread the funds among all the towns, resulting in completion of only 49 percent of the planned works. While construction quality was good, flooding continued – in four cases, severely. The reasons: the partial systems were ineffective; the towns did not have funds for maintenance so drainage was often blocked; and buildings were allowed to encroach on the open storm drains. Unregulated development has further exacerbated flooding.

Source: (IEG 2008).

3.58 The rushed nature of emergency response projects makes them particularly vulnerable to design and institutional problems. In the wake of a disaster, emergency recovery projects often take advantage of heightened awareness of risks to galvanize prevention of future catastrophes. But emergency projects may not have sufficient time to design, or get political buy-in for, the institutional reforms necessary to achieve preventive actions – as in the case of the Cambodia Flood Emergency Rehabilitation Project. Rushed planning in emergency projects can also lead to poor design decisions, as in Honduras and Turkey. And some emergency projects that have attempted to set up more complex mechanisms have failed. (See Appendix I2 for details.)

3.59 Little evidence is available on cost-effectiveness or impacts of flood protection projects. Most projects do not undertake an economic analysis of flood protection benefits (emergency projects do not have to), and even when such analysis exists the variation in methodology makes comparisons difficult. Of the 27 project ICR reviews, only 5 calculated an ERR. These returns ranged between 10-40 percent, and used varying methodologies. The lowest estimate comes from a methodology based on observed changes in property prices in the protected area. The most advanced economic analysis is for a flood protection project in Poland (World Bank 2007), which incorporated hydrological modeling that estimated the shift in the probability distribution of different flood events due to the project investments. It estimated an ERR of 17.4 percent on a nearly €500 million investment. No consistent evidence is available on loss of life reduction or on poverty or gender impacts.

MANGROVE CONSERVATION AND PLANTING

3.60 Mangroves provide critical environmental services including provision of timber and nontimber products, fishery habitats, carbon storage, and biodiversity conservation (Barbier 2012). Mangrove planting and conservation is frequently cited as an important application of ecosystem-based adaptation, through provision of coastal protection benefits while also preserving biodiversity (World Bank 2010b; World Bank 2010c). Over 1990-2011, the Bank completed 16 projects²⁹ that supported mangrove conservation or planting components, of which 8 identified coastal protection as a project impact (even if coastal protection was not necessarily an objective or goal of the project). Performance across these projects was variable, depending on the degree of planting which was achieved, the type and quality of mangroves planted and method of planting, the institutional setup and incentives, and the incidence of storms in the period when mangroves were immature. (See Appendix I3 for details.)

3.61 Better quantification of the economic and non-economic benefits of mangroves could aid in adaptation planning. Mangroves have been shown to reduce mortality from cyclones (Das and Vincent 2009) and to provide fishery and timber income. However, existing estimates of benefits are spotty and often flawed or incomplete due to methodological problems. (See Appendix H2 for a summary of the valuation literature.)

3.62 Ecosystem-based adaptation planning could also benefit from a deeper understanding of the costs of mangrove projects and the determinants of their sustainability. Little is known about the sustainable performance of closed Bank mangrove projects in the Bank portfolio, because the precise location of the plantations was not recorded. Without these records, it is impossible to check on the mangroves' long-term survival or protective impact. The sustainability of benefits depends on the ability to create long-term institutions and incentives to retain wetland areas as

mangrove. Mangrove areas are more likely to be sustained when locals derive economic value from the presence of mangroves or where protection contracts exist that pay locals to retain mangrove coverage (WRI 2011). Sustainability of mangroves is also highly dependent on the opportunity cost; it is difficult to get local support for mangroves in areas where locals can get high returns from shrimp farming if mangroves are cleared. Conservation is easier to achieve in low-value areas unsuitable for other purposes, but often few people live in these areas and so the value of coastal protection services is modest. Long-term mangrove sustainability is also threatened by to climate-change-driven sea level rise if mangrove wetlands are unable to migrate inland due to topography or development.³⁰

FINANCIAL RISK MANAGEMENT

3.63 Even with the best preventive efforts, not all disaster damage can be prevented. If nothing is done, some of this risk falls painfully on poor people and governments. Insurance and other financial risk management instruments allow the financial costs of disaster to be shifted toward people who are able spread those risks across a diversified portfolio, cushioning the pain. These instruments can target private individuals or public entities.

Accelerating Private Sector Disaster Insurance Adoption

3.64 The Bank has initiated attempts to accelerate penetration of private disaster insurance, which is very low in developing countries. The South East Europe Catastrophe Risk Insurance Project aims to increase private insurance penetration in southeast European countries by creating an insurance company that will offer high-quality products (initially Serbia, FYR Macedonia, and Albania). The company will offer indemnity insurance for flood and earthquakes and temperature and precipitation index insurance to households, enterprises, agribusiness, and government agencies.³¹ The Romania Catastrophe Insurance Pool also aims to increase insurance penetration, but through a more government-oriented model. The project has been successful in increasing the number of people insured, with insurance coverage for homeowners increasing from 5 percent to 40 percent. But premium and reinsurance fees remain low and it remains unclear whether the product will remain commercially sustainable.

Financial Risk Management for Governments

3.65 Given low coverage from private insurance³² and the unreliability of donor funds, governments are likely to continue to be responsible for much of disaster response and reconstruction. Countries face two kinds of financial risk management needs. The first, discussed here at length, is the urgent need for immediate liquidity to

fund disaster response.³³ The second need is to access the massive funds needed for reconstruction after a major catastrophe.

3.66 Historically, the Bank has often helped meet post-disaster liquidity needs by diverting funds from existing projects. In recent years, the Bank has moved away from reallocations,³⁴ and has supported two instruments (insurance through a risk pool and contingent credit lines) that can assist in providing post-disaster liquidity directly.

3.67 The *Caribbean Catastrophic Risk Insurance Facility* offers a successful example of a multicountry insurance risk pool. The facility is designed to reduce the impact of natural disasters by providing member countries with insurance payouts sufficient to cover short-term needs in the aftermath of an earthquake or hurricane. The facility has been successful in offering insurance at a lower rate than would be available had each country tried to purchase insurance separately or if each country maintained its own reserve fund, and is generally viewed positively by member countries.. (See Appendix I4 for details.)

3.68 A more widely applicable instrument is the Deferred Drawdown Option for Catastrophe Risk (CatDDO). The CatDDO is an instantly available credit line for IBRD clients, designed to cover immediate expenses of disaster response. For an upfront fee of 0.5 percent (and an annual renewal fee of 0.25 percent), the client can set up a credit line of up to \$500 million or 0.25 percent of GDP, whichever is less. This is only a fraction of the cost of a typical catastrophe, but it provides cash when time is of the essence. The credit line is activated when the client declares a state of emergency for a natural disaster. Since the Cat DDO became available in 2008, 7 countries have adopted the instrument.³⁵

3.69 The Cat DDO offers some opportunities for influencing disaster risk management policy. Like all DPOs, it is linked to prior policy actions. A hazard risk management plan is a prerequisite for eligibility, and this is reflected in some prior actions. For example, the Costa Rica Cat DDO specified prior actions including adoption of a national emergencies and risk prevention law, creation of a national emergency fund, and incorporation of a disaster risk management policy into the national development plan and screening for national investment projects. Other Cat DDOs have similar prior action requirements. While the possibility of gaining access to the DDO may encourage countries to improve their disaster planning, such actions have generally been devised as part of broader national disaster management strategies (sometimes supported by the Bank or GFDRR) and driven by a country desire to improve disaster planning, rather than being tied directly to a DDO operation. The Cat DDO enables the Bank to work on disaster risk management with Ministries of Finance (rather than with traditional civil defense/disaster relief agencies), which has more

ability to mobilize significant financial resources for risk reduction and is better suited for undertaking ex ante financial risk management.

3.70 But some aspects of the instrument's design discourage its adoption. The full value of the credit line is counted against World Bank country borrowing limits, and so countries near their borrowing limit may prefer to access World Bank funds through DPOs or standard development loans, rather than commit a portion of their borrowing limit to a credit line that may never be activated. In order for the credit line to count for less than full value against country borrower limits, the credit line would need to be activated by a parametric trigger. If the trigger was set by parameter (such as a hurricane of a specified magnitude) then it would be possible to calculate the probability that the credit line would be activated. This would allow the credit line to count for less than full value against borrowing limits. But country control of the trigger is a central part of what makes the instrument appealing to borrowers—it provides liquidity to countries when they need it—and formal estimation of disaster probabilities would require significant data availability and would increase transaction costs. The Inter-American Development Bank introduced a contingent credit facility with a parametric trigger in 2009, but as of July 2011 only the Dominican Republic had adopted the facility.

3.71 The Cat DDO has several advantages, but is not suited to all countries. The instrument appears to be successful in meeting post-disaster liquidity needs; credit lines disbursed funds within weeks of activation, and countries with Cat DDOs have not reallocated funds from existing Bank projects for disaster response, nor have they required disaster-related emergency projects. The Bank estimates that Cat DDO costs are 25 percent below the cost of equivalent insurance (United Nations and World Bank 2010).³⁶ The DDO may also be politically preferable to a reserve fund. It can be politically difficult for countries to build up large reserve funds since there are many pressures for alternative uses of funds, but by using the drawdown option instead a country can get the post-disaster liquidity it needs and then credibly commit to repaying the loan. The Cat DDO may also be preferable to a reserve fund if a reserve fund is seen as too expensive (that is, if the country has a very high opportunity cost of capital). But a country with good investment opportunities might wish to borrow up to its IBRD limits rather than maintain an unused credit line. Very large countries may be better off to self-insure. Highly indebted countries cannot afford to take on further debt, and so may not be good candidates.

3.72 Importantly, IDA (low-income) countries are ineligible for the Cat DDO instrument. Low-income countries typically have poor disaster preparedness and severe liquidity constraints, and so potentially have a great deal to gain from post-disaster credit lines. But in its present form, the Cat DDO is available only to IBRD countries. IDA countries use their full borrowing allocation, and so have nothing to gain

from setting this aside to set up a contingent credit line. Additional donor funds would be required in order to offer a Cat DDO to IDA borrowers, either through a special IDA allocation, through particular donors offering guarantees, or potentially through climate change adaptation funding. These funds could be used to offer a contingent credit line at IBRD lending rates for disaster-prone IDA countries that was made available following a disaster of specified magnitude³⁷.

3.73 While there has been some success with these instruments, they are not designed to cover the vast majority of disaster damage. Developing countries remain largely exposed to disaster losses, and most coverage occurs through ad hoc support from donors. The Bank has attempted to fill this gap by supporting use of a catastrophe bond. A catastrophe bond is a debt instrument that pays a set coupon amount unless a disaster of at least a specified magnitude occurs, in which case it pays nothing. Thus, the bond acts to spread catastrophic risk from the issuer to the purchaser. The World Bank Treasury has acted as the arranger for a \$290 million multi-catastrophe (hurricane and earthquake) bond issued in 2009 by Mexico's national disaster fund, the first such multi-catastrophe bond in the world by a national government. An IFC attempt to create a reinsurance company that would provide disaster coverage was unsuccessful due to the lack of interest from technical partners.

3.74 There is little scope for widespread use of catastrophe bonds by Bank Group clients. The catastrophe bond requires a very high level of client capacity and financial sector experience, and the global market for such bonds remains small even in developed countries. (The total value of outstanding bonds is \$13 billion (Munich Re 2011). Bank support for catastrophe bonds in the near future will likely remain limited to providing technical support to a small potential pool of clients. Reinsurers and financial markets demand very high markups over an actuarially fair premium,³⁸ in part because of the extreme uncertainties over the probabilities of catastrophic disasters, which will be exacerbated by climate change. At these prices, the welfare gain from transferring this risk elsewhere may not be worth the cost, and governments may be better off retaining the risk. The Bank Group may be more effective in increasing the ability of clients to manage catastrophic events by improving client disaster risk management capacity, and by investing in data collection systems that will reduce the uncertainty faced by disaster modelers.

CONCLUSIONS ON DISASTER RISK MANAGEMENT

3.75 There has been a significant shift in the Bank's approach to disasters, toward a proactive risk management and risk reduction approach, and there has been widespread success in mainstreaming disaster risk management into sectoral operations. But most operations still use traditional risk reduction approaches; more

high-quality analytic work is needed to demonstrate the effectiveness of ecological-based and non-structural methods.

3.76 Most of this support has been aimed at coping with high-frequency disasters or in covering urgent liquidity needs for more serious disasters. There remains a significant financing gap for catastrophic coverage, and attempts to address this through support for catastrophe bonds are unlikely to provide much impact.

Hydromet Services

CONTEXT: UNDERINVESTMENT, UNDERUSE, AND UNCAPTURED BENEFITS OF HYDROMET SYSTEMS

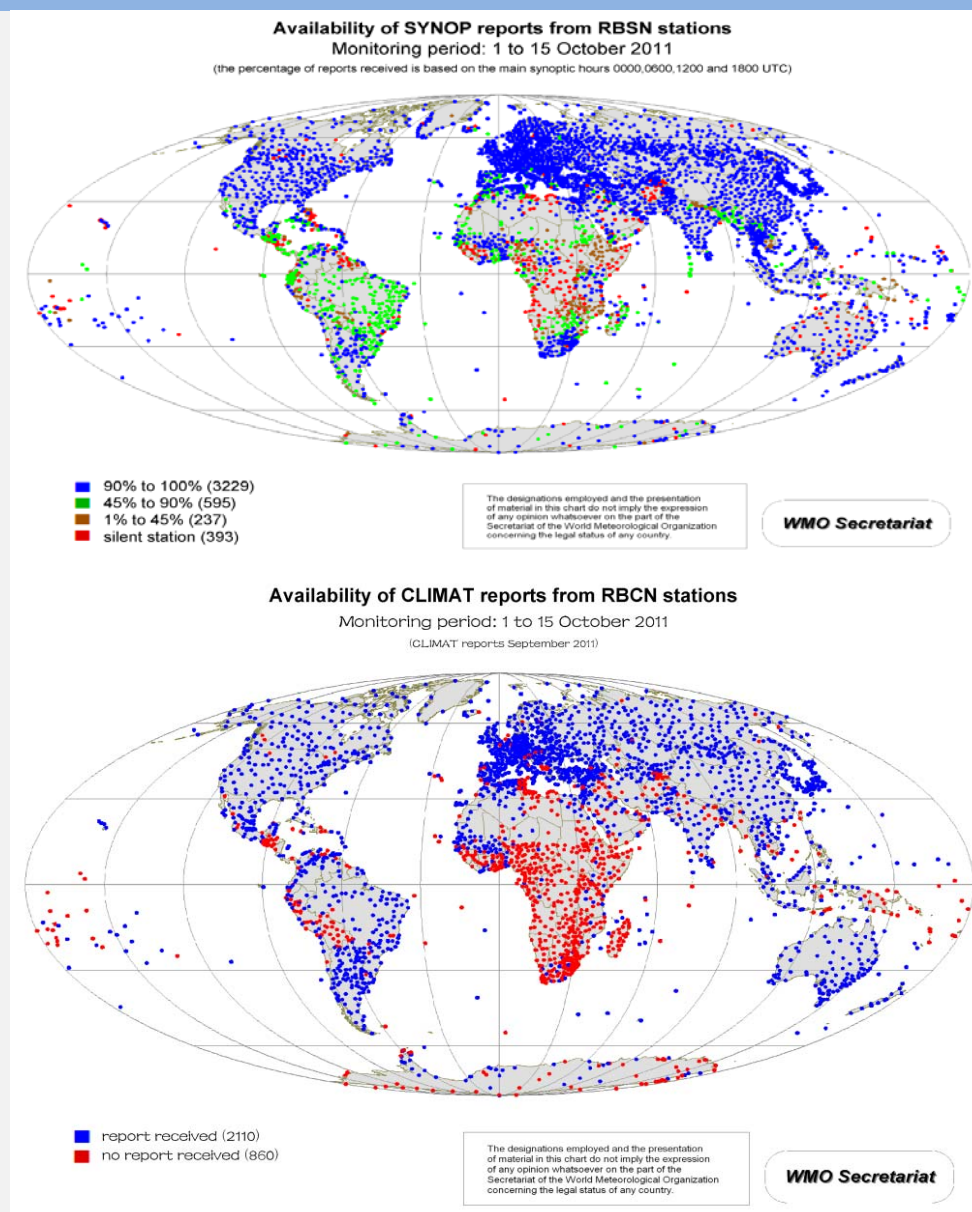
3.77 Hydrometeorological information offers a wide range of potential benefits for ACV. Hydromet systems produce disaster warnings that allow for preventative actions that reduce the damage done by climate disasters. Farmers can move livestock to high ground before floods; cities can prepare roads for heavy snowfall; dam operators can start reducing reservoir levels and so reduce the peak flood size. Non-disaster weather forecasts also provide economic benefits: farmers need to know when it will rain so they can avoid having their fertilizer washed away. And there are indirect benefits from having a long record of hydromet data. Rainfall data is an input into the modeling work needed to create weather insurance products. River flow data is needed to design and estimate the benefits from irrigation systems or hydropower plants. In addition, all forms of climate data help improve the calibration and validation of long-term climate models, contributing to ACC.

3.78 There are strong reasons to expect hydromet data to be underprovided and underused. First, hydromet data is a public good. It is expensive to create, but costs relatively little to broadcast and share. Such public goods should be publicly funded. But if cash-strapped countries spend too little on hydromet agencies, the agencies may be forced to sell data, shutting out some people who might benefit. Second, hydromet data is a network good. Denser networks make for more accurate forecasts at the regional or global level, but countries may not take account of these spillover benefits when planning their own network of weather stations. Third, there is a chicken-and-egg problem with data supply and demand. Until people understand the benefits of weather forecasts, there may be little demand for hydromet data. But without demand, agencies may be unwilling to invest in expanding their systems.

3.79 In both developing and developed countries, hydromet data are often not freely shared, despite World Meteorological Organization mandates. (Peterson and Manton 2008; Viglione., Borga and others 2010) In part, this is because underfunded hydromet agencies sell data to support their operations. But there is often a lack of data-sharing between meteorology and hydrology agencies even within a country.

3.80 Low investment is especially evident in Africa. The network of hydromet stations is sparse and deteriorating, and hydromet data are often spotty and inaccurate. Existing stations are often not functioning or fail to communicate with the global meteorological network (Figure 3.3). These shortcomings are especially serious given the large proportion of Africans engaged in agriculture and the very high variability of African precipitation relative to the mean.

Figure 3.3. Status of Weather Stations, 2010-11



Top panel: SYNOP data (daily reports)

Bottom panel: CLIMAT data (monthly climatology)

Source: World Meteorological Organization, http://www.wmo.int/pages/prog/www/ois/monitor/index_en.html

3.81 Efforts to improve hydromet services offer potentially high economic returns. GFDRR (Subbiah, L. Bildan and others 2008) estimates returns of 165 percent to 568 percent for early warning systems and seasonal forecasts. World Bank estimates of five-year benefit:cost ratios for hydromet investments in South Eastern Europe ranging from 1:1 for Montenegro to between 7:1 and 11:1 for Serbia (UN International Strategy for Disaster Reduction Secretariat - Europe, World Bank and others 2008). A study of Russia (World Bank 2005) estimated benefit:cost ratios of 4.5:1 to 10:1 for hydromet modernization, motivating a large Bank loan. Economic rates of return for hydromet investment projects in Tajikistan and the Kyrgyz Republic were estimated at 23.6 percent and 53.4 percent, respectively (GFDRR 2010). These estimates are intuitively appealing, but sometimes flawed (see Annex F2). Better economic analysis would be helpful to screen and motivate investments in low-income countries. Analysis is needed also of the returns to “data rescue.” This involves digitizing handwritten archives of hydromet observations – a low-cost activity that could, for instance, boost the reliability of hydropower or irrigation project appraisal, and improve the calibration of climate models.

WORLD BANK EXPERIENCE

3.82 Over 1985-2011, the World Bank has financed 132 projects that supported hydromet improvements.³⁹ Twelve projects provided comprehensive support for national-level hydromet systems at a cost of \$380 million. About nine-tenths of project funding went to 8 IBRD countries (Albania, Brazil, Dominican Republic, Mexico, Peru, Poland, Russia, and Turkey), while the remainder went to 4 IDA countries/regions (Afghanistan, Central Asia, Moldova, and Sri Lanka). An additional 120 projects (including 18 in Sub-Saharan Africa and 5 in the Middle East and North Africa) supported partial systems or specific needs, at a cost of at least \$917 million.

NATIONAL-LEVEL PROJECTS

3.83 Five national hydromet systems (NHMS) projects have been completed and evaluated.⁴⁰ These were all in disaster-prone middle-income countries, and four of the projects immediately followed national climate disasters. Consequently, the projects all aimed at improving early warning systems while also upgrading their hydromet monitoring systems.

3.84 All five countries were able to upgrade their systems, and prospects for sustainability looked good in most. IEG’s 2005 evaluation of the Turkey project found forecasting achievements to be sustainable, and a 2011 assessment (United Nations Development Programme, World Meteorological Organization and others 2011) suggests that the additional equipment funded under the Bank loan (363 stations) is still in use eight years after the project closed. The same assessment states, however, that

only half of Turkey's stations are currently operational. In the Dominican Republic, maintenance was highlighted as a major problem, since it had been neglected in the past and was likely to be neglected in the future.

3.85 Capacity building—for equipment operation and for forecasting—was successful in all five countries, although difficulties remained in the Dominican Republic. CONAGUA in Mexico, for example, developed the ability to provide accurate 96-hour weather forecasts. Both CONAGUA and IMGW of Poland have become sources of leadership and capacity building for other countries.

3.86 All five of the closed projects improved domestic information sharing between agencies. Peru overcame the greatest challenge, since four agencies had to coordinate to produce El Niño forecasts. With the help of Bank staff, all four agencies overcame their initial differences and committed to financing these activities for at least 10 years. In Turkey, cooperation between the hydrological and meteorological services was reported to be inadequate but improving (United Nations Development Programme, World Meteorological Organization and others 2011).

3.87 The design of the seven ongoing projects often reflects lessons learned in prior projects. There is continued emphasis on data-sharing, especially in Central Asia, where the project promotes systems integration among participating countries. In contrast to the earlier projects, five of the ongoing projects were designed with specific users or beneficiaries in mind.

3.88 Attention to hydromet is increasing. The PPCR has decided to emphasize hydromet investments. It has identified \$95 million in investments in 11 country programs.

PROJECTS IN AFRICA, PAST AND PRESENT

3.89 As noted, Sub-Saharan Africa deserves special attention because of the poor state of its hydromet system and its high level of climate variability. Over 1990-2010, 24 World Bank projects involving partial hydromet systems were approved; 12 are closed and evaluated. Hydromet expenditure totaled \$52 million for the 15 African projects where funding information was available, against about \$1.4 billion for the rest of the world.

3.90 The projects have had some successes in improving early warning systems, as noted regarding Kenya. In the Senegal River Basin, a project expanded upstream monitoring in Guinea and integrated this information into the Basin hydrological network. Early warning projects in Burkina Faso and Cameroon continued to function after the projects closed. However, a project in Zambia failed to achieve coordination

between the four institutions involved in early warnings, which continued to operate in isolation from one another.

3.91 Maintenance continues to be a problem. Only four of the 12 closed African projects reported attention to maintenance and only in the Senegal River Basin did the self-evaluation report consider sustainability to be likely.

3.92 Automated systems would seem to be one solution⁴¹ — but experience so far has not been encouraging. The World Meteorological Organization (WMO) has warned that automated equipment is not necessarily cheaper or more reliable than human observers.⁴² Two recent experiences bear this out. The new project in Central Asia found that automated equipment from a prior project could not be maintained, due to operating conditions, lack of staff capacity, and difficulty in getting spare parts. Consequently, the project invested more heavily in traditional manual instrumentation. Second, the World Bank helped finance the Weather Information for All Initiative, which proposed an innovative solution for Africa in partnership with private sector telecommunications companies. They sought to add weather stations to cell phone towers, solving power, connectivity, and security problems. However, the nonprofit coordinating agency went bankrupt, and only 19 of the 5,000 planned stations had been erected by 2011.

3.93 Ultimately though, supply is not enough. Unlocking strong demand for weather, hydrological, and climate info is necessary in order to sustain the political will to maintain hydromet services.

Dealing with Climate Variability: Conclusions

3.94 There is a large unfinished agenda in closing the adaptation gap: increasing people's resilience to current levels of climate variability. Sustainable land and water management and the expansion of efficient irrigation can fight poverty and improve agriculturalists' resilience. So, too, can disaster risk management, including drought mitigation and relief. These agendas overlap with what has been considered sustainable development.

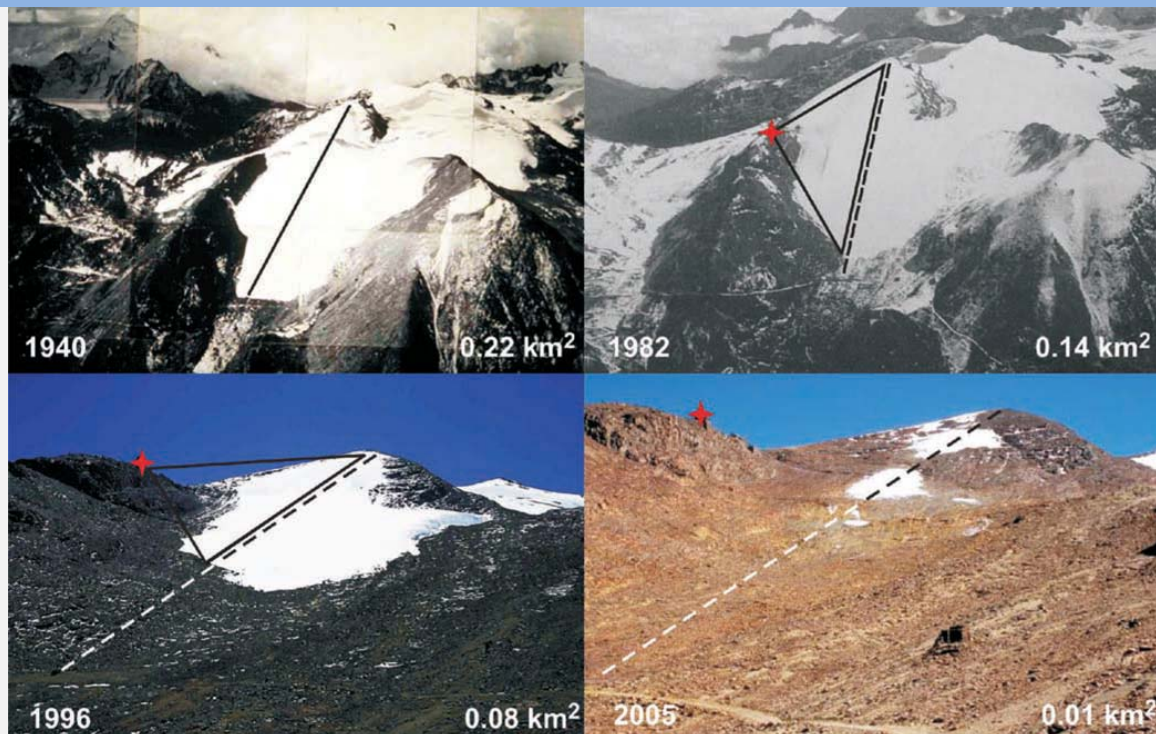
3.95 A key question is the extent to which these activities also promote adaptation to long-term climate change. Agroclimatic zones are shifting, so techniques that are adaptive today may not be suitable 20 years hence. Population growth and migration are exposing more people to climate risks, potentially counteracting progress in risk reduction. The next section assesses how consideration of long-term climate change can be factored into decision making in policies and investment, and looks at nascent experience in doing so.

4. Anticipatory Adaptation to Climate Change

Highlights

- ❖ Climate models have been more useful for setting context than for informing investment and policy choices. They have limited reliability for decisions involving precipitation extremes in small areas.
- ❖ Although hydropower has a long tradition of dealing with climate variability, the Bank Group lacks guidance on appropriate methods for incorporating climate change considerations into project design and appraisal.
- ❖ Land use planning is, in theory, critical to anticipatory adaptation for disaster exposure reduction, coastal zone management, and biodiversity conservation. But experience and success are limited.
- ❖ The Bank has begun to incorporate ACC into biodiversity projects, but few projects have had the goal of conserving biodiversity that could be critical for agricultural adaptation.

Figure 4.1. Glacial Retreat in Bolivia



These images show the retreat of the Chacaltaya Glacier in Bolivia, an illustration of long-term transformational climate change impacts.

Source: Cynthia Rosenzweig, NASA. http://www.giss.nasa.gov/research/briefs/rosenzweig_02/

Image credits: IPCC Working Group II Fourth Assessment Report 2007; 1940 Servicio Aerofotográfico Nacional, Bolivia; 1982 Reinhardt & Jordan; 1996, 2005 Bernard Francou

4.1 Climate *variability*—as manifested in storms, floods, and droughts—is a familiar component of risk for investors in many sectors. Climate *change* is something new. This section is a report from the front lines as the Bank Group and others grapple with the implications for risk management and planning. It starts by asking the normative questions:

- When is it important to factor climate change into decision making? When is it necessary to cast decisions (perhaps literally) in concrete—as in the case of the Padma Bridge—based on anticipated changes over coming decades? When is it sufficient to adapt-as-you-go, as in the case of the Cartagena causeway? When is climate change simply not an important factor?
- Where anticipatory adaptation is necessary, what is the basis for decision making? What are the uses and limits of global and regional climate models?

4.2 As noted elsewhere (and elaborated here) the answer to the first question is that anticipatory adaptation is most important for investments or decisions that are inflexible or irreversible, and have long lifetimes or lead times. The section looks at hydropower as an exemplar of long-lived, climate-sensitive infrastructure investments. Hydropower is particularly germane because of its well-developed methods for dealing with climate variability, and because it was singled out for screening in the SFDCC. (Annex E briefly discusses roads.) The section concludes with large-scale, long-range planning issues related to land use and agricultural technologies.

Normative Theory of Incorporating Climate Risk into Project Planning

4.3 Climate change has two distinctive features that complicate decision making. First, it plays out over decades, with the worst impacts furthest in the future. Second, while the broad outlines of climate change are clear, there is much uncertainty about particular impacts at particular locations. This brings to the fore three dimensions of decision making: incorporating flexibility, discounting future costs and benefits, and projecting future conditions.

FLEXIBILITY

4.4 Projects are more affected by climate *change* (relative to climate *variability*) if they are long-lived and expensive to adjust or retrofit. Table 4.1 motivates the choice of the three sectors chosen for discussion in this chapter. Short-lived projects will not see much change in their fundamental economics due to climate change and may need to focus much more strongly on climate variability. Road surfaces, for instance, are typically rebuilt every 15 or 20 years and can be adjusted to meet current climatic and traffic conditions. The causeway in the Port of Cartagena can easily be raised when sea

level rise begins to threaten it. In contrast, hydropower facilities may have a design life of 100 years, and it is often difficult to heighten a dam or expand a reservoir after construction. Most sensitive are projects that are both inflexible and have indefinite time horizons. An example is the conservation of unique ecosystems, protecting them against today's threats with the goal of maintaining them for future generations. Another is the layout of major transport corridors, which can shape development patterns for centuries (Box 4-2.).

Table 4.1. Project Flexibility and Longevity

Flexibility	Life of <20 years	Life of 20-100 years	Life >100 years
Adjustable	Road paving	Cartagena causeway	
Inflexible or irreversible		Hydropower facilities Padma Bridge piers	Samoa: road routing choice Protected areas

DISCOUNTING

4.5 Stern and others have advocated using low and declining discount rates to assess climate-sensitive decisions that involve intergenerational tradeoffs at the global level (Stern 2007; Weitzman 2007).

4.6 Different criteria would seem to apply to decisions by Bank Group clients on how to assess climate-related financial risks in typical investment projects. Public and private clients have high opportunity costs, often 15 percent or more. Gradual, climate-related changes in flows of costs and benefits are likely to have little impact on investment decisions. Consider a hypothetical climate sensitive project with a baseline 15 percent return each year, but where these returns decline linearly by a fifth over a 30-year period due to climate change—for instance, a hydropower plant confronting a decline in average precipitation. With a 30-year investment horizon, climate change reduces the economic rate of return of the project by less than one percentage point, from 14.8 percent to 14.0 percent. This is likely too minor a change to affect investment decisions and may be small compared to more immediate risks, such as construction cost overruns.

4.7 It is important to stress, however, that some aspects of decision making are not ordinarily considered in a discounted value framework. This is especially true for investments with environmental or health impacts. For example, dam safety standards require the ability withstand a particular flood event (such as a 1 in 10 thousand year flood), and environmental flow requirements are set to require a particular minimum flow level. If, for instance, meeting those standards requires building a stronger dam today to withstand the worst-case floods of 2112, then climate change considerations could have a significant impact on project economics.

USES AND LIMITATIONS OF CLIMATE MODELS

4.8 Scientists have developed an increasingly sophisticated suite of computerized models in order to understand human impacts on climate change. Global climate models (GCMs) project climate at a coarse resolution, typically 2.5° latitude x 2.5° longitude (77,000 square kilometers or larger). Regional climate models (RCMs) or statistical downscaling methods zoom in on smaller areas (at resolutions as fine as 20 x 20 kilometers), using GCMs as input. GCMs have been essential for climate change research and for assessing global pathways to climate stabilization. As noted in chapter 2, models have been useful in developing countries in raising awareness, setting the context for national-level action, and building technical capacity

4.9 It has been irresistible to press these newly developed scientific models into service for guidance in practical project and program planning and analysis. The Bank has done so, sometimes in cutting-edge ways. The Bank also has supported local capacity building in the development and use of these models. But can these models provide the kind of information required by development planners and infrastructure designers (see Table 4.2)? Can they, for instance, indicate how the magnitude of 1 in a hundred year floods will change in a particular watershed?

4.10 Climate projections are built on an accumulation of uncertainties that limit their precision for certain purposes (IPCC 2007):

- There is uncertainty about the exact values of key physical parameters. Rowlands, Frame, and others (2012), for instance, run thousands of variants of a single climate model using equally plausible values for these parameters, and obtain mean global warming estimates ranging from 1.4 to 3.0° C by 2050.
- Different scientific groups have constructed competing models, and there is no agreed means of discriminating among them. (Ability to reproduce current climate conditions is no guarantee of the model's predictive ability under unprecedented future conditions.)
- The ability to calibrate the models is limited by sparse observational data in many parts of the world (see Figure 3.3), and this applies especially to locally downscaled models.
- The models may be particularly challenged by mountainous regions, which are expected to be particularly sensitive to climate change.
- Local and global climate, and climate change, impacts are strongly modulated by unpredictable human actions over the coming century, including the degree of greenhouse gas emissions, deforestation, and water use.
- There is inherent, chaotic variation in weather, not just day to day, but year to year and even decade to decade. Thus, a single climate model will (correctly) generate a range of different possible realizations of future climate patterns.

Table 4.2. Information Needs for Anticipatory Adaptation Decisions

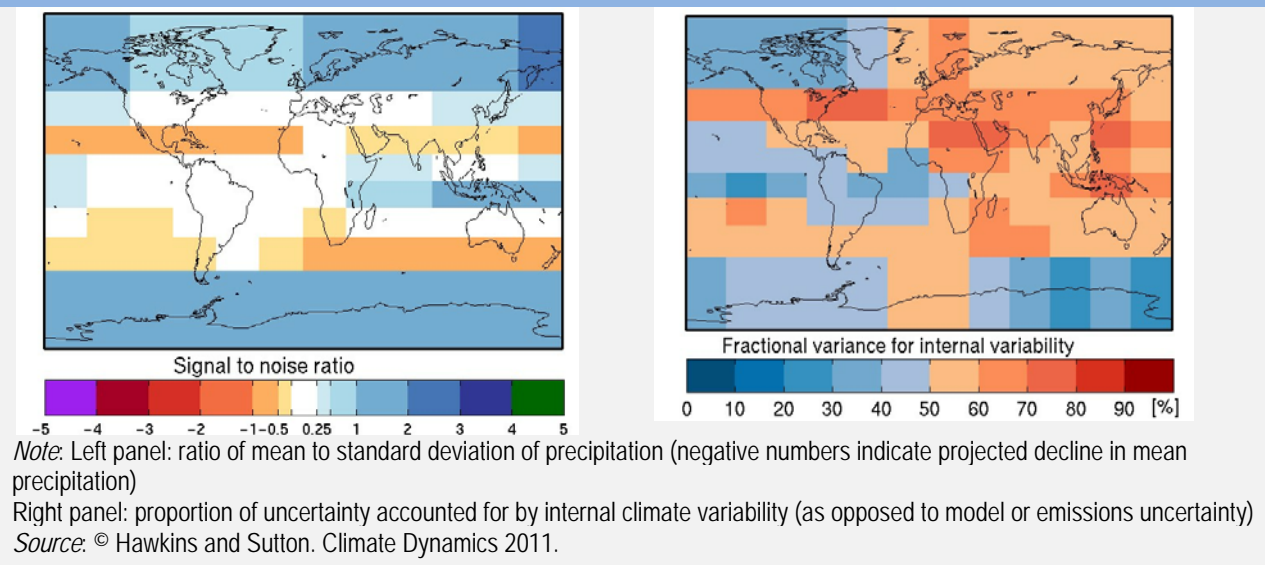
Case	Sample climate-related questions	Information required	Timescale	Other relevant information
1. Road network, Ethiopia	What are the potential climate impacts on road assets and transport services, with associated costs for adaptation?	Annual number of days with heat waves and 10-year high rainfall event for road design	10-50 years	Traffic volume and overloading; maintenance regime
2. Trung Son Hydro Project, Vietnam	What are the expected economic returns under various scenarios for future hydrology and power generation?	Exceedance probabilities of dry season rainfall and low flows	10-40 years	Capital costs of alternative options, fuel prices, avoided greenhouse gas emissions
3. Rainfed and irrigated agriculture, Yemen	What is the vulnerability of agriculture and rural livelihoods to climate variability and change?	Annual rainfall, reservoir inflow, evaporation and groundwater recharge	10-80 years	Agricultural water demand; water governance
4. Hydropower plants, Albania	What steps can be taken to improve energy security and dam safety under extreme weather?	Probable maximum flood or 10,000 year flood for dam spillway	100 years	Land use restrictions
5. Urban drainage in Kolkata, India	What are the relative benefits of de-silting, upgrading, or building new sewers?	Exceedance probabilities for rainfall and floods of various magnitudes	10-50 years	Land subsidence and expansion of impermeable surfaces
6. Padma Bridge, Bangladesh	How deep and high to make the piers?	Sea level and scouring intensity by 100 year flood	100 years	Likelihood of earthquakes

Source: IEG.

4.11 Hawkins and Sutton (2009) (2011) provide some guidance on the degree of climate model uncertainty. They predict global and regional temperature and precipitation, on a seasonal basis, using 15 different climate models and 3 different scenarios for future emissions, giving a range of possible outcomes. The variation among outcomes is partitioned between “internal” (natural or intrinsic) climate

variability, uncertainty about the climate model, and uncertainty about the emissions scenario. Hawkins and Sutton report on the proportion of total uncertainty that is accounted for by internal climate variability, and on the size of uncertainty (“noise”) relative to the mean prediction of climate change (“signal”). Figure 4.2 (left panel) shows, for example, the “signal:noise” ratio for December-February precipitation change 20 years from now. For areas shown in white, light blue, or light orange, the average projected change is swamped by uncertainty. The right panel shows that in the Eastern Hemisphere, most of this uncertainty is due to internal climate variability. This suggests that for projects dependent on winter precipitation, with a time horizon of less than 20 years, it might be more important to attend to climate variability than to climate change.

Figure 4.2. Map of Uncertainty in December-February Precipitation Projections at a 20-Year Horizon

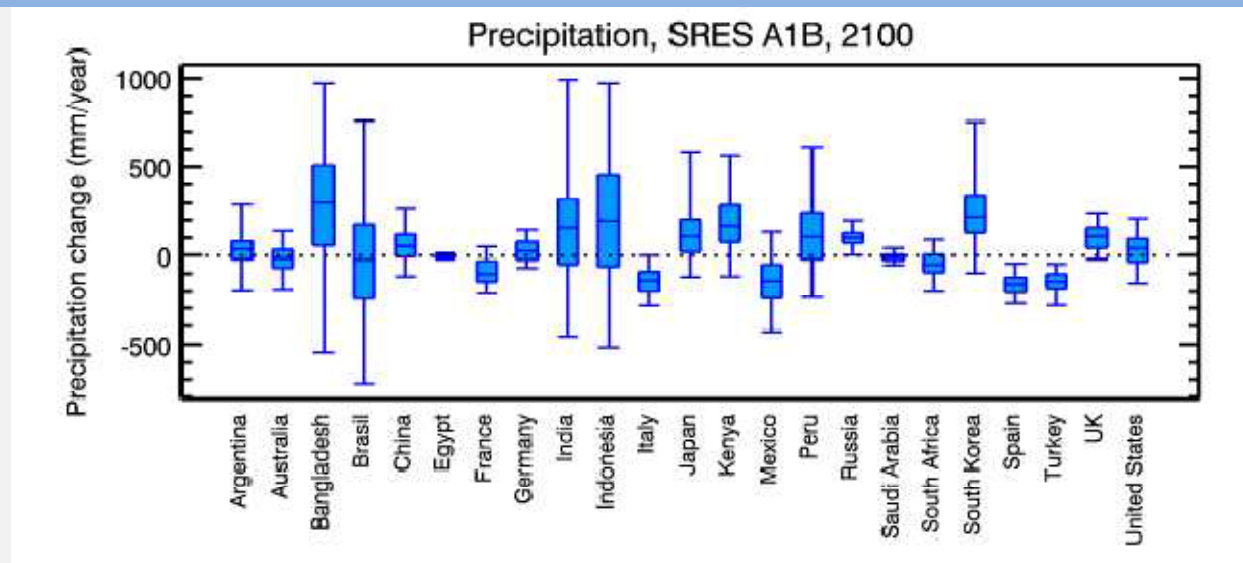


4.12 Key findings from Hawkins and Sutton are as follows:

- Temperature projections are relatively reliable; uncertainty is small relative to the trend.
- Precipitation projections are much less reliable at all time and geographical scales. Typically it is not possible to determine whether mean precipitation is increasing or decreasing, and both outcomes are possible (Figure 4.3).
- For time horizons of 30 years or less, internal climate variability is the main source of uncertainty about precipitation.
- Relative uncertainty is higher for smaller geographic areas, and for seasonal versus annual means. By extension, uncertainty becomes very high for projections about extreme events in particular places.

- For horizons of 30 years or less, uncertainty about the emissions scenario makes little difference.

Figure 4.3. Precipitation Projections across Models, 2100



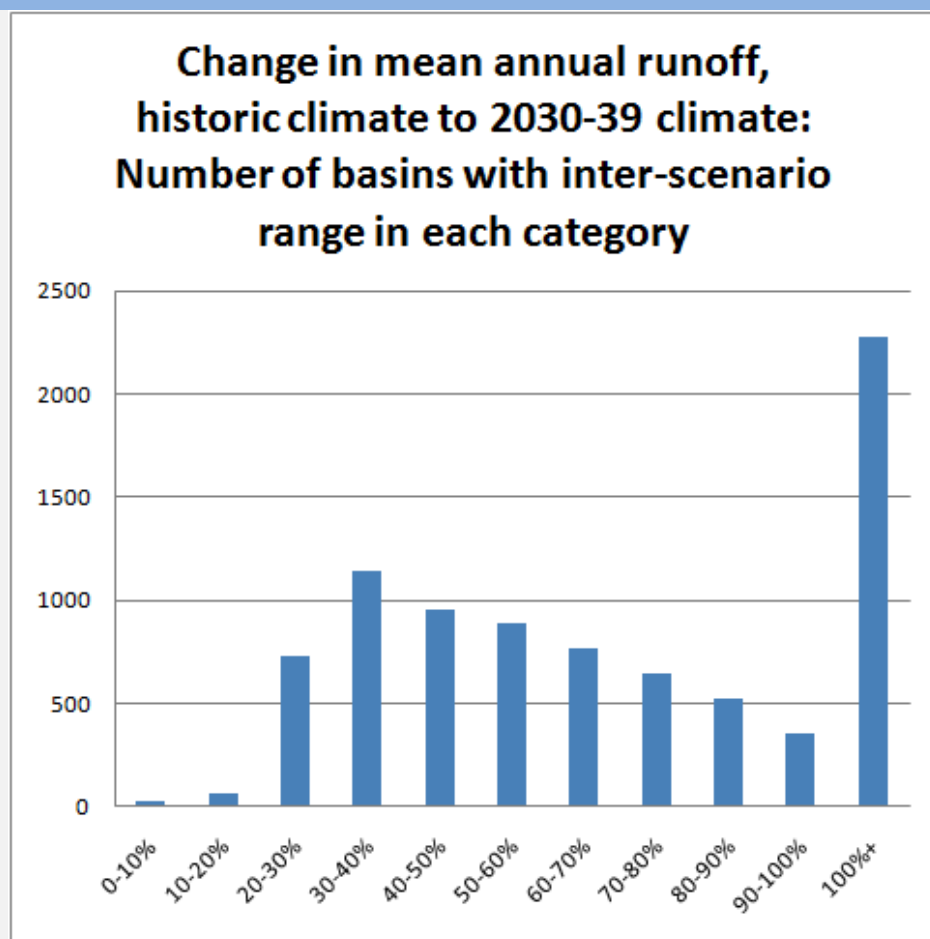
Note: This shows a set of analyses by the Hadley Centre on the change in national level mean precipitation to 2100, under a high-emissions scenario. For Bangladesh, Brazil, India, and Indonesia the ranges are immense—on the order of 1.5 meters/year—encompassing both wetter and drier possible futures for each country. This complicates adaptation planning. Planning would be difficult enough if one knew for sure that climate was going to be much wetter, or if it were certain to become much drier. But based on current information, either outcome is possible. Bars give 25th, 50th (median), and 75th percentiles; whiskers show maximum and minimum across models.

Source: Met Office, Hadley Centre. "Climate: Observations, projections and impacts." Downloaded from <http://www.metoffice.gov.uk/climate-change/policy-relevant/obs-projections-impacts>

APPLICATIONS OF CLIMATE MODELS AT THE WORLD BANK GROUP

4.13 Precipitation uncertainty is reflected in a dataset assembled by the World Bank's Water Anchor intended to inform development planning (Strzepek, McCluskey and others 2011). The projections are distributed on the Bank's web-based climate portal. The authors caution that the projections are not suitable for project-level work, because of their coarse scale. This dataset consists of projections of hydrological flows for 8,380 river basins. For each basin, up to 22 GCMs and 3 emissions scenarios were used to drive a hydrological model of impacts on water flows. Figure 4.4 tabulates the ranges between highest and lowest flows across the 8,380 basins. For more than two-thirds of the basins, the range of projection is more than 50 percent of the historic average. For about a quarter of the basins, the range is more than 100 percent.

Figure 4.4. Spread of Hydrological Predictions for River Basins



Note: Number of river basins with data = 8,380; 54 emission scenario/GCM combinations used for each basin: interscenario range = highest change—lowest change, expressed in percentages of historical baseline level
Source: IEG analysis of data described in (Strzepek, McCluskey and others 2011) and available at World Bank Climate Portal.

4.14 IEG also reviewed 28 recent studies and project documents that used GCMs to address climate change, to determine how the models were used and how the analyses dealt with uncertainty in projections. (These were opportunistically chosen and may not be comprehensive of all such projects, programs, and studies. A comprehensive survey of recent hydropower projects is discussed in chapter 4.) The analysis cross-classified the type of climate scenario modeling against how the climate models were used to discriminate among options.

Table 4.3. Scenario and Adaptation Option Methods Used by Surveyed World Bank Studies

Scenario method	Options analysis				
	Not done	Low-regret (robust)	Adaptively managed	Precautionary principle	Cost-benefit
<i>Qualitative</i>	1	2	0	0	0
<i>Sensitivity test</i>	2	0	½	1	2½
<i>Scenario-led</i>	5	10½	½	1	2

Scenarios:

Qualitative: Refers to primary sources (such as IPCC) and/or applies simple climate narratives (such as hotter, warmer, drier, or earlier).

Sensitivity test: Application of arbitrary climatic (and non-climatic) change factors to the inputs driving model(s) of the system(s) of interest

Scenario-led: Applies top-down approach to quantify outcomes arising from combinations of emissions, climate model, downscaling, and impact model uncertainty

Options analysis:

Low-regret (robust): Largely qualitative appraisal of scenario-neutral measures that should realize benefits under present climate variability as well as future climate change

Adaptively managed: Flexible operations, forecasting, or innovative use of existing infrastructure to meet emergent climate trends and/or changes in variability

Precautionary principle: Apply a safety margin for managing risk and uncertainty

Cost-benefit: Monetization of adaptation options under climatic and non-climatic scenarios. Includes robust decision making with emphasis on "satisficing" rather than determining optimal solutions.

Source: IEG (Half values are used for four projects that each use two methods of adaptation option analysis.)

4.15 The review found that climate model information has generally been unable to inform quantitative decision making in the surveyed studies. Most studies adopted a traditional scenario-led approach to making climate projections. But over half of the studies then recommended low-regret adaptation options that do not depend on climate projections, and roughly one-quarter did not recommend adaptation options. In some cases, climate projections were used to outline potential climate futures to inform sensitivity-testing of project viability (Trung Son hydro, Kolkata flooding). Only in a handful of cases were numerical predictions used as in input into design (Padma bridge, Kiribati high-tide calculator).

4.16 In retrospect, the Bank Group has pioneered — often in innovative ways — the use of climate models, but has discovered that they often have relatively low value-added for many of the applications described in Table 4.2. An alternative approach would emphasize robust decision-making methods, where the analytic emphasis is on understanding how different investment options are sensitive to a range of possible climate outcomes, rather than on attempting to predict the future climate (Box 4-1). It would emphasize adaptive management, where policies and investment programs are updated over time as future uncertainties are realized. And it would ensure that

capacity-building programs in client countries prioritized practical hydrometeorological, decision-making, and design tools.

4.17 However, the models in some cases may be able to point to broad trends that have implications for regional planning, especially where temperature is the key variable. For instance, Lobell, Schlenker and others(2011) shows that crop yields are more closely linked to temperature than to precipitation, and points out that there is greater agreement on temperature trends than on precipitation trends. In some cases, there is good agreement among models with respect to regional precipitation trends. This was the case for the Zambezi Basin, for instance, where the basin-level projections described above agreed on a trend toward decreasing precipitation. Model outputs can be used to communicate qualitative climate risks and to outline a broad range of future possibilities. And modeling may be a necessary part of due diligence for megaprojects.

Box 4-1. Robust Decision Making and Climate Change

Not only are we uncertain about which future climate scenarios will occur -- we can't even reckon the odds of experiencing one scenario versus another..⁴³ This means that traditional probabilistic risk analysis is not suitable for choosing between options that are highly sensitive to future climate change. How then should we proceed?

Robust decision making (RDM) offers an alternative, as a technique suited to making decisions in the presence of deep uncertainty. It can be used as a qualitative approach to decision making, or as a formal computational method. In either case, the outcome is to select options that perform well across a range of plausible future scenarios. The approach offers a way to integrate climate uncertainty with uncertainty about important economic factors or key parameter values.

Recent World Bank studies have suggested use of RDM in the context of green growth and climate change adaptation. RDM tools have been used in a number of cases, including for selecting flood risk mitigation options in New Orleans (Fischbach 2010) and for water planning in California(World Bank 2009b), and are currently being used for preparing an integrated flood management plan for Ho Chi Minh city(World Bank 2012). Sometimes these studies can help to refocus the debate away from climate uncertainty: the work in New Orleans concluded that the key factors for determining the best vulnerability reduction policies were not the impact of climate change, but rather the effectiveness of homeowner buyout policies, the rate of degradation of levees and the degree to which elevating houses would reduce flood damage.

Box 4-2. Samoa's Dilemma: Coast Road or Inland Road?

The most important road in Samoa goes from the airport to the capital. It is subject to damage from storms and tsunamis—they have hit before and will hit again. (A tsunami on the less-settled south coast in 2009 inflicted damage equal to 10 percent of GDP.) The existing road needs major rehabilitation due to storm damage and insufficient maintenance. These circumstances offered a choice: should Samoa rehabilitate the existing coastal road, or construct a new route further inland? The coastal road is where the existing development is—but will likely suffer further damage and outages due to storms, and the risk will steadily increase as sea levels rise. An inland road would be more climate-proof—but would cost a quarter of Samoa's GDP. How then to proceed?

A Bank-sponsored study in 2003 favored the inland option based largely on distance and time savings from the more direct route. (The study assumed a limited access highway rather than a road that would provide greater access and benefits to people along the corridor.) A second Bank-sponsored study in 2010 confirmed feasibility of the inland route, and made detailed recommendations about route selection.. A 2010 feasibility study by the Samoan Land Transport Authority indicated a general level of support and commitment for the road project from villages along the proposed route, but highlighted concerns about social impacts and resettlement. But investigations carried out under the World Bank-funded Samoa Infrastructure Asset Management Stage II project highlighted the high costs of the inland proposal, involving complex land and resettlement issues, time-consuming access negotiations and likely high compensation costs.

In the end, Samoa decided to proceed with the coastal rehabilitation, and to commence studies that would allow them to revisit the inland route in another 20 years. The rehabilitation work aims to reduce road closures and flooding by improving drainage and road pavement. But a further 20 years of coastal development may only increase the difficulty of moving the road inland. An open, and difficult, question is whether an inland route would catalyze a new, alternative spatial pattern of development, reducing the economy's exposure to hazards—but imposing differential costs and benefits on coastal and inland landholders.

Sources: IEG, World Bank staff, project files.

Climate Change and Hydropower Investments

NORMATIVE CONSIDERATIONS

4.18 Designing and operating hydropower facilities requires a good understanding of climate variability and watershed function. For profitable operation, reservoir capacity and generating capacity need to be matched to the level and variability of water flows. If capacity is too small, benefits are forgone. If capacity is too large, capital is wasted. Dams also have to be able to withstand severe floods. Hydropower engineers and hydrologists have developed sophisticated modeling tools in order to meet these design challenges.

4.19 Climate change affects hydropower in several ways:

- *Average annual flows could change.* Higher temperatures will increase evaporation from reservoirs, decreasing flows. Climate change could increase or decrease precipitation and runoff, affecting power generation and profitability.
- *Flows could become more variable, day-to-day, seasonally, or year-to-year.* Loss of snowmass and glaciers means more flow in winter and less in summer. Climate change is expected generally to increase the variability of flows. These changes affect the economics of hydropower by requiring larger reservoirs. Run-of-river plants (with no reservoirs) become less attractive because of the lower capacity utilization. The tradeoff between power and environmental flows becomes sharper.
- *Catastrophic floods could get worse.* To meet desired levels of safety, dams may need to have more spillways, adding to costs.

4.20 These anticipated, but uncertain, changes could affect today's investment decisions via these channels:

- *Safety provisions.* Project analysis does not discount future risks to lives or to the environment, instead relying on standards. For instance, dams may be required to withstand a 1000 year flood or a "probable maximum flood." Since dams may stand for a century or more, anticipated changes between now and 2100 in this design flood affect today's structural decisions and costs.
- *Environmental impacts:* Declines in total water flows could result in tensions between maintaining power output and maintaining environmental flows.
- *Profitability and investment decisions.* In the near term, changes in patterns of runoff will probably be slow relative to existing variability (except in areas facing rapid snowmelt.) Changes in runoff two decades or more from now have comparatively little impact on investment returns if discount rates are high. Still, rapid or highly uncertain climate change combined with low discount rates, and climate-driven safety provisions could affect the attractiveness of hydro investments.
- *Design factors.* If well anticipated, climate change could alter the optimal capacity of a plant.⁴⁴ In the presence of uncertainty, it may be desirable to build flexibility into current designs. For instance, space may be left for installation of additional turbines to allow for the possibility of increased flows in the future; dams can be designed to enable future increases in dam height.

4.21 While many public agencies have put in place broad requirements that water resource infrastructures should incorporate climate change, no guidelines specify how this should be done (Vescovi, Baril and others 2009; Stutley 2010; Brekke 2011; UK Environment Agency 2011; USAID 2012). Hydropower project managers are thus left in limbo – pressed to incorporate climate change characteristics by agencies that are increasingly concerned with climate change adaptation, but without any operational guidance on how and when to do so.

ANALYTIC STUDIES

4.22 The Bank Group has undertaken some state-of-the-art analytic studies of climate impacts on hydropower operations, using GCMs. These studies are more extensive and sophisticated than standard appraisal techniques, and provide insights into the nature and magnitude of impacts, and into the uses and limits of climate projections in project planning. Three completed studies are described in Appendix F3; more are underway.

4.23 The usefulness of modeling varies widely. A regional study of the Zambezi Basin (Strzepek, Boehlert and others 2011) found a consistent signal of decreasing rainfall among 56 different climate model/scenario combinations. This coarse-grained model could not make specific recommendations, but indicates that the tradeoffs between growth (power production), poverty (employment in irrigated agriculture), and environment (the region's rich wetland and river-dependent biodiversity) are steep and would motivate a more in-depth look at options for energy and water conservation in the basin. In contrast, an assessment of the prospects of a recently installed Nepalese powerplant (Stenek, Connell and others 2011b) was stymied by divergent precipitation forecasts, a schizophrenic historical record of flows, and a lack of information about local snowpacks. Global models are poor at representing the monsoon rains upon which this region depends, and fine-scale local models would be stumped by Himalayan topography, even assuming that adequate historical weather data were available. So climate impacts could not be assessed, and the study recommended no-regret and low-regret adaptation measures. A third study, for a facility in Zambia (Stenek, Boysen and others 2011) indicated that allowance for climate change would not significantly affect the economics of the investment. It also illustrated that planned operating rules for the dam – maintaining minimum reservoir levels – could be incompatible in the long run with maintenance of high flows of water to the Kafue flats, an environmentally important wetland.

WORLD BANK GROUP PRACTICE IN INCORPORATING CLIMATE CHANGE INTO THE DESIGN AND APPRAISAL OF HYDROPOWER FACILITIES

4.24 IEG analyzed the appraisals of a sample of nine recent Bank Group-financed large hydropower projects for their treatment of climate variability and change (Table 4.4). These were SFDCC-era (post FY08), selected based on size and on availability of information. Projects were assessed for the length of hydrological record used; for their analysis of the risks to the investment posed by low flows under current climate variability; and for whether and how design and appraisal considered climate change risks. Note that many projects are presented for finance, especially to the IFC, at an advanced stage of preparation and design.

Table 4.4. Hydropower Project Designs Evaluated by IEG

Project	Type RR=run of river S= Storage	Testing of low flow sensitivity?	Testing of climate change?	Length of hydrological record used	Dam safety standard
IFC #1	RR	Y	N	35 years	N/A
IFC #2	Multiple projects, RR and S	N	N	N/A	PMF
IFC #3	S, glacier fed	Y	N	N/A	10,000 year flood
IFC #4	RR from glacier	Y	N	N/A	50-100 year flood for different components*
Rampur (World Bank)	Downstream of another project with storage, glacier fed	Y	Y	41 years	10,000 year flood
Trung Son (World Bank)	S	Y	Y	50 years	1,000 year flood
IFC #5	Multiple projects, S, some limited S	N	N	40-50 years	N/A
IFC #6	RR, small portion glacier fed	Y	Y	42 years	N/A
IFC #7	RR	Y	N	N/A	N/A

Source: IEG analysis based on available documentation and staff interviews.

Note: N/A = not available. *This facility has a low dam the failure of which would not be catastrophic.

4.25 Treatment of climate variability was inconsistent. The five projects where record length data were available used at least 35 years of data, which is sufficient for estimating average flows – on the traditional assumption that climate is not changing. One project used only the most recent 35 of a 60-year record because of a perceived local climatic shift, a procedure that may underestimate existing climate variability. Six of the nine projects included at least some consideration of climate variability (most commonly by testing sensitivity to tenth percentile low flows), but for three projects there was no indication of consideration of climate variability. Of the projects that considered climate variability, two looked at the impacts of low flows on the IRR (investment rate of return) or ERR, two others looked only at the impact on the ability of the project to service its debt, and no details were available for two other projects. (Appraisal of an earlier IFC project based its assessment of flow reliability on a 59-year record. Shortly after commissioning, the project suffered two exceptionally dry years in a row. This, combined with construction cost overruns, halved the expected IRR.)

4.26 Three projects explicitly assessed impacts of climate change on river flows and project economics. One project used climate models to examine the potential range of

future climate outcomes, while others did sensitivity analyses to assumed worst-case scenarios. For the projects that did consider the possibilities of climate change, the economics of the projects were so favorable that even poor climate outcomes would not make the projects unviable. For example, the Rampur project identified an existing downward trend in river flows, but found that the project would remain viable at a discount rate of 12 percent even if the trend worsened by a factor of 5. But these analyses considered only changes in average flows; no project considered the potential impact of changes in the seasonal distribution of river flows. No projects considered the possibility of adaptive management.

4.27 Some projects demonstrated a backward-looking approach to climate change; five of the IFC projects did not consider the impact of climate change on river flows because they did not observe a trend in their historic data series. This rationale seems questionable; the potential for climate change impacts over the economic life of the project should be informed by a forward-looking approach that considers qualitative climate model projections, reliance on glacier or snowmass, or other factors.

4.28 Treatment of dam safety varied across projects, but seemed reasonable. With no clear guidance on how to incorporate climate change into choosing safety standards, project designers usually selected a conservative standard and counted on this to be sufficiently high even under a changing climate. In one case, World Bank project involvement led to a higher safety standard than had initially been planned (Box 4-3).

Box 4-3. Trung Son Hydropower: A Practical Approach to Climate Risk

A \$412 million hydropower project in Vietnam financed by the World Bank stands out as a model for mainstreaming climate change considerations into hydropower design. The project undertook an independent hydrological analysis to confirm the results of the primary analysis. An economic analysis of the project considered the potential impacts of climate change in a simple and practical way; it looked at existing projections for changes in precipitation in northwestern Vietnam drawn from country work carried out by the Vietnamese Environment agency, and used these to guide the bounds of sensitivity analysis for low-flow possibilities. It turned out that the project was robust to low flows and that the project would remain viable even in the most pessimistic climate change scenario where average flows dropped 26 percent by 2035. Average flows would have to drop by half in order for the expected economic rate of return of 18.9 percent to fall to the 10 percent hurdle rate.

Knowing that climate models were unable to predict with precision the possibility of future extreme flood events, the project design instead chose to mitigate the possibility of dam failure. Bank involvement in the project led to adoption of a safety standard that could withstand a 1 in 1,000 year maximum probable flood event (as calculated based on the historic river data). The project design also incorporated a secondary “fuse dam” (which would breach in the event of a 1,000 year event, protecting the main dam by allowing a secondary outlet to the reservoir), and it used zoning and warning systems in the flood zone to reduce the potential loss caused by a breach.

Sources: IEG, (World Bank 2011d), (Meier 2011); staff.

Land Use and Climate Change Adaptation

4.29 The world has seen accelerating land use change, including conversion of forest, range, and wetlands to agriculture, and of floodplains and coastlines to urban settlements. These changes will continue throughout the century as demand for food grows and as urban populations swell by billions. They are often effectively irreversible, shaping spatial patterns of development for centuries to come.

4.30 Unconstrained land use change could increase long-term climate vulnerability in two ways: by increasing the exposure of populations and infrastructure to storms and floods, and by constraining the ability of ecosystems to adapt to changing temperatures.

CLIMATE CHANGE, LAND USE, AND BIODIVERSITY

4.31 The World Bank Group is the largest financier of biodiversity projects in the world, largely through support for protected areas. But will these protected areas sustain biodiversity over the long term as the climate changes?

Normative Considerations

4.32 Climate change will transform ecosystems in many ways, threatening the survival of some (Bellard, Bertelsmeier and others 2012). Many species are temperature-sensitive. As temperatures rise, they will tend to migrate toward the poles and uphill. Changes in runoff and evaporation will affect wetlands and riverine ecosystems. Coral reefs will suffer increased bleaching or reduced calcification due to heat stress and ocean acidification. Reduced yields from agriculture may lead to additional pressure for land clearance or stress on high altitude areas. More frequent wildfires will disrupt the balance of fire-dependent ecosystems. Glacier retreat and snowmass melting will affect water availability in high-altitude ecosystems. Ecosystem linkages are further stressed when interrelated species (predator/prey, pollinator/plant) separate in space or in lifecycle timing.

4.33 The clearest prescription for adaptation is to maintain the ability for species to migrate in response to climate change (Hannah 2011). This requires ensuring connectivity between existing habitats. Connectivity does not necessarily require a continuous biodiversity corridor, but it requires, at least, the conservation of stepping-stone habitats within a broader biodiversity-friendly landscape. The network of habitats should include, if possible, microclimates that could be stable in the face of climate change. As habitats are converted to intensive farming or urban developments, options for this kind of conservation and connectivity are irreversibly shut. Ecosystem adaptation will require, in addition, a broad range of efforts to reduce current ecological stress imposed by people (Dawson, Jackson and others 2011).

Integration of Climate Change Consideration in World Bank Protected Area Projects

4.34 IEG examined the portfolio of biodiversity and protected area projects approved between 2009 and 2011. Of 34 projects, 8 considered the sensitivity of the project to climate change, of which half explicitly supported species migration through biodiversity corridors, while the other half assumed that reducing non-climate threats would support increased climate resilience in vulnerable ecosystems. Appraisals for 6 projects described the future threats of climate change in detail. Three projects supported climate vulnerability assessments and identified mitigation measures. All 8 projects proposed concrete actions to assist in climate change adaptation, including reforestation, creation of buffer zones, and preparation of management plans. Proposals were generally based on thorough studies and assessments of local adaptation needs.

4.35 Monitoring climate change adaptation in protected areas is still in its infancy. Only three projects made provisions to monitor successes and failures of climate change adaptation for biodiversity conservation. A further three projects included monitoring systems that did not include climate change considerations in their design, while the remaining two projects did not implement monitoring systems.

MACROZONING OF RURAL LAND USE

4.36 Conservationists have long advocated zoning of rural land use to maintain biodiversity and ecosystem processes. Sophisticated optimization techniques have been proposed to achieve ecological goals at least opportunity cost in foregone agricultural production.

4.37 Experience in land use regulation is mixed. On average, formal protected areas have reduced tropical deforestation. Protected areas that allow sustainable land use have been more successful than strictly protected areas. In Latin America, putting areas under the control of indigenous people has been extremely successful in deterring deforestation (Nelson and Chomitz 2011). However, macrozoning that attempts to regulate private uses of land has historically been unenforceable. Bank-executed zoning projects in Rondonia and Mato Grosso failed when they imposed restrictions on powerful ranching and timber interests. In Indonesia, 40 million people live in areas zoned for forests but lacking trees.

4.38 A new approach appeals to banks as an instrument of enforcement. In Brazil, banks are beginning to decline to make loans to farmers and ranchers whose land is out of compliance with regulations. The Western Cape Province (South Africa) uses zoning to impose EIAs on those who would convert critical biodiversity areas (Box 4-4).

Box 4-4. Spatial Planning for Biodiversity Conservation in South Africa

The Cape Floristic Region (CFR) is a biodiversity hotspot of global significance. While the world's other five floristic regions are continent-sized, the CFR occupies a corner of a single province, and contains 9,000 plant species, 69 percent of them endemic. Its survival is threatened both by climate change and by conversion of natural vegetation to agriculture.

With help from a Bank/GEF project, the Western Cape province developed a 20-year plan for conserving biodiversity. The plan involved developing a framework for spatial development planning. The follow-on Biodiversity Conservation and Sustainable Development Project elaborated this framework. After broad consultation on priorities and principles of land use zoning, the implementing agency, SANBI, applied sophisticated optimization tools to a set of fine-resolution maps of the region's biodiversity and natural resources. The output was a spatial conservation plan—a map of plots of land to be conserved. The plots were chosen to represent the complete range of the province's biodiversity and maintain important ecological processes while minimizing the number of hectares dedicated to conservation. The resultant top-down map of biodiversity priority areas was incorporated in state and district spatial development plans.

There are strong economic incentives for farmers to flout the land use plans. Potato and rooibos (an indigenous herbal tea) farms are expanding into the fragile lands of the Sandveld and Cederberg Mountains. Against these pressures, three instruments are deployed. First, the municipal plans—but these appear to be indicative, for the most part. Second, a quasigovernmental agency, Cape Nature, offers very modest incentives for landholders to sign conservation agreements. About 71,000 hectares have been signed to permanent, binding agreements, including in other parts of the Province. Potentially the most effective instrument is the requirement for any landholder who wishes to convert native vegetation to file an Environmental Impact Assessment (EIA). The EIA must note whether the conversion area impinges on a biodiversity conservation area; if so, the application may be denied, or banks may decline to finance the expansion. Illegal expansion is easily detected, since telltale irrigation circles are unmistakable on Google Earth. But penalties for failure to file an EIA are weak, and some stakeholders believe that the Agriculture Department is more sympathetic to expansion than to conservation. It will become evident within a few years whether the conservation plan is successful.

Sources: ICR; project documents; IEG site visit.

EXPOSURE REDUCTION

4.39 Urbanization and development in disaster-prone areas are the main driver of vulnerability to climate disasters, particularly in coastal cities and floodplains (IPCC 2012). So studies of flood adaptation (including the Bank's) often call for land use zoning and spatial planning to nudge urban development toward safer areas on higher ground (World Bank 2010a, 2011a, 2011b; Jha, Bloch, and others 2012).⁴⁵ Between now and 2050, urban populations in the developing world will grow by 2.5 billion people. Will those new settlers be directly in the path of storms and floods? Development patterns could be shaped through regulation, infrastructure placement, and incentives. Although benefit-cost studies

are lacking, such policies could be cost-effective, given the tendency for vibrant urban growth to crystallize around a small initial development. Slightly higher initial costs could be repaid by much lower expected disaster costs in the future. (See Box 4-2. on Samoa's choice of spatial development patterns.)

4.40 However, it is difficult to find effective examples of land use zoning or spatial planning for exposure reduction. Within cities, land use zoning is difficult to enforce. It is difficult to keep developers from capitalizing on high value though risk-prone urban real estate, or from draining wetlands that provide citywide flood prevention benefits. It is hard to keep poor people from settling in low-value areas exposed to the greatest risk; creation of alternative housing opportunities is necessary, but may not be sufficient in the face of urban migration. Resettlement of existing residents is fraught with the potential for harming the most vulnerable if not done well.

4.41 The World Bank has little experience in implementing urban spatial planning and zoning,⁴⁶ but it has had some small-scale successes. As noted in chapter 3, a Brazilian water quality and control project created and maintained green spaces for flood overflows by designating them for parkland and soccer fields, ensuring popular benefits and support. Over 5,000 families were successfully relocated out of high-risk areas. State governments were required to demonstrate *ex ante* that funding was available for new land acquisition and for construction for those resettled by the project.

4.42 The Bank has supported some successful examples of resettlement out of disaster-prone areas. In Argentina, a Bank-supported flood protection program adopted an assisted self-construction strategy, where poor and low-skill residents whose houses had been damaged or destroyed by floods were trained in construction and received material assistance in building homes in safer areas (Pérez and Zelmeister 2011). In Colombia, a Bank-supported disaster risk reduction project successfully undertook preventative resettlement of households in the Nueva Esperanza neighborhood of Bogota out of areas exposed to landslides in flooding (Poveda Gómez 2011).

4.43 Overall, resettlement as a risk reduction strategy has happened in relatively few Bank projects. Involuntary relocation can be a politically sensitive issue for clients. Bank safeguard policies (appropriately) require careful management and monitoring of any involuntary resettlement. Preventative resettlement is seen as difficult and labor intensive, rather than as a regular part of a disaster risk management toolkit. Together, these mean that Bank staff face weak incentives for undertaking projects that reduce exposure. And individual resettlement programs financed by the Bank are likely to have only a modest direct impact on global exposure to natural hazards.

4.44 More effective than resettlement of existing populations would be to institute zoning that will shape future development patterns at large scale over a long period. The largest ongoing such effort is an ambitious Integrated Coastal Zone Management Project in India. Approved in 2010, the project supports creation and public dissemination of hazard maps for the 100 year coastal flood event and the 100 year erosion line for the entire coastline of India (at a cost of \$80 million, including support for creation of a new national center for coastal zone management). Delineation of these zones will take climate change into account by incorporating future sea level rise projections up to 2110, though its estimates of storm surge will be based solely on historic data. The project will then use these maps to delineate coastal planning areas throughout the country, and will finance development and initiation of integrated management plans for these areas in three pilot states (at a cost of \$200 million). The plans will attempt to balance security of life and livelihood (including disaster exposure) with pollution management, resource conservation, and livelihood improvements, which may include limiting development in vulnerable areas. Demarcation of flood lines with ground markers may also encourage private adaptation or exposure reduction by individuals and firms.

4.45 The Bank is also providing technical assistance (TA) to India on spatial development options in the climate-threatened Sundarbans. (See **Error! Reference source not found.**) The TA found that a number of apparently adaptive actions were in fact maladaptive, locking populations into increasing exposure to risk. The TA proposes measures for immediate risk mitigation (such as improved early warning systems and cyclone shelters) but also envisions a long-term spatial and human development plan which reverses earlier maladaptation.

PREPARING FOR LONG-TERM AGROCLIMATIC TRANSITIONS

4.46 Climate change will impose severe stresses on agricultural systems, necessitating changes in what is grown where. Some stresses are predictable. Current grain varieties are highly sensitive to temperature spikes over 30° C – each day above that threshold reduces yields by 1.7 percent under drought conditions (Lobell, Banziger and others 2011). Hillside crops such as coffee are also sensitive to temperature change. Because hillsides are warming and temperature spikes increasing, these crops will not continue to be viable in their current form in their current location.

4.47 The public policy implications for spatial planning are unclear, but deserve investigation. Production areas for commercial crops may have to relocate. Entire areas may need to transition between different kinds of agriculture. Can these transitions be accommodated purely through private sector responses? There could be a role for public policy in information provision, extension services, credit, and infrastructure. As a first step, ongoing analytic work in the Bank is assessing the implications of climate

change for spatial patterns of agriculture in Brazil. This needs be complemented by analyses of the economics of responding to agroclimatic shifts.

Box 4-5 From maladaptation to adaptation in the Indian Sundarbans

A recent World Bank executed Non-Lending Technical Assistance (NLTA) in West Bengal, India, is a good example of integrating long-run anticipatory adaptation efforts into development planning.

The Sundarbans, straddling India and Bangladesh, are part of the great mangrove-dominated delta facing the Bay of Bengal. The Indian portion is home to more than 4 million poor and climate-vulnerable people. Their average per capita annual income is \$180, and 70 percent lack access to safe water. Many live at or below sea level and are at constant risk from floods and cyclone. They endure creeping salinization as the sea rises; about a third of the farmland already has high salinity. Productive landholdings average just 0.36 hectares and are likely to shrink as population grows.

The NLTA found that many well-intentioned and apparently adaptive activities in fact were maladaptive, boosting long-run vulnerability. Most importantly, the seemingly protective 3500 km system of embankments, dating to the nineteenth century, is literally undermining itself. The embankments constrict tidal flows, which then erode the embankments' foundations. Inadequate water resources management by aquaculture activities and rising sea levels place further pressure on the embankments. Attempts to reinforce them just make them heavier and less stable. When hit by storm surges, the walls fail, with disastrous consequences.

The NLTA recognized the need to deal with today's urgent poverty challenges but concluded that business-as-usual-development is not sustainable in the long run. River channels are too narrow even for current tidal flows, due in part to climate change over the past century. The combination of rising seas and subsiding land will increase the flows, and will make lower-lying portions of the delta increasingly uninhabitable.

In response, the NLTA proposes that the Sundarbans embark on a multigenerational plan to re-engineer estuary management and consider options to enable and motivate welfare-improving voluntary outmigration from the most threatened areas. Where channels are too narrow, the indefensible embankments would be moved back by 100 to 350 meters over a period of 20 years. Flood-threatened farmland would give way to river and mangrove, requiring a managed retreat that would be difficult but would prevent future catastrophes. Starting now, increased attention to education would equip new generations with the skills to seek better livelihoods in India's cities as they expand over coming decades. Infrastructure and policies would be targeted towards encouraging development in the less-threatened parts of the Sundarbans. The preferred outcome would be that the most threatened parts of the area would eventually be allowed to revert to mangrove, expanding the rich and threatened ecosystem and boosting prospects for sustainable, profitable, ecotourism. (This is a home of the Royal Bengal tiger.) This long-term vision would be complemented by immediate actions to set up early warning systems, build a network of cyclone shelters, improve health, water and sanitation services, and enhance cooperation among the many agencies concerned with the Sundarbans.

In sum, the NLTA illustrates the need to think now about how to shape long-term spatial and human development patterns in order to create a more sustainable and resilient future.

Sources: Battacharya Pethick, and Sensarma, K (forthcoming) World Bank (forthcoming)

Agricultural Research and Development, Including Conservation of Genetic Resources

4.48 Climate change will expose many agricultural systems to locally or globally unprecedented stresses, including heat, drought, flood, salinity, and emergent strains of pests. While it may be difficult to anticipate the precise needs of precise locations, there could be an argument for publicly supported prebreeding of crop varieties with desirable traits (Guarino and Lobell 2011). The availability of such a portfolio could cut short the 10-12-year lead period required to breed some species to meet local conditions.

4.49 The CGIAR (Consultative Group on International Agricultural Research), with funding in part from the World Bank, is supporting this kind of research and development, targeting smallholder farmers. Recent reform in the CGIAR has led to the initiation of an array of large research programs, one of which is on climate change. The focus in this CGIAR research program includes work on adaptation through better management of agricultural risks associated with increased climate variability and extreme events and accelerated adaptation to progressive climate change via technology, agronomy, and policy options. Several other CGIAR research programs and individual center activities dealing with crop and livestock improvements have a climate change dimension.

4.50 Funding the creation of these public goods and supporting countries to be able to adapt new knowledge and technologies developed elsewhere is key to extending the benefits of location-specific research and development. The IEG evaluation of agriculture and agribusiness (IEG 2010a) recommended that the World Bank work with partners to ensure that CGIAR research is translated into benefits in client countries. The World Bank is a major donor to the CGIAR, providing \$50 million annually to the system's core budget. This funding is totally fungible and is not specifically tied to climate change activities. Besides providing core funding, there is little evidence that the World Bank has worked directly with individual centers or with the Consortium of CGIAR Centers to shape the agenda in agriculture and climate change adaptation. IEG correspondence with scientists in the centers suggests that the level of interaction between the Bank and centers is often ad hoc, limited in many cases to informal interactions and sharing of research results.

4.51 Several Bank documents mention the importance of strengthening the links between World Bank and the CGIAR, but there are no guidelines for direct incorporation of CGIAR research and research results into Bank operations. Progress in extending the benefits of science in adapting to climate change requires that many developing countries have the ability to adapt new knowledge and technologies that lead to more sustainable and resilient agricultural systems. However, many public

research organizations in developing countries face serious institutional and capacity constraints. Sustained World Bank support through greater focus on national and regional-level research and development and systems for transferring knowledge to smallholders would enhance the effectiveness and ability of developing countries to benefit from scale economies in creation of public goods that help farmers adapt to climate change.

4.52 Underlying the development of new varieties is a need for conservation of genetic diversity in food crops and animals. Many staples and commercially important crops and animals lack genetic diversity, making them potentially widely susceptible to climate-related stresses, such as emerging pests. For instance, there is very little diversity in commercially cultivated *arabica* coffee. A potentially important response would be to conserve the wild relatives of current crops, which may harbor genetic traits needed for an altered future (Guarino and Lobell 2011). This has been done in seed collections, but there is a strong argument for also conserving these resources *in situ*, that is, in the wild. This would allow them to coevolve with climatic and ecosystem conditions (Hunter and Heywood 2011).

4.53 Although the Bank is a leader in investing in protected areas (with GEF support), it has only made five investments in *in situ* agrobiodiversity conservation. This is a striking contrast, given that it is much easier to argue that agrobiodiversity has monetizable benefits, as compared (for instance) to rainforests that are appreciated for the rarity and uniqueness of their noncommercial species.

Conclusions

4.54 The Bank Group, like others, lacks guidance on how best to incorporate climate change considerations into the design and appraisal of infrastructure projects, and current practice is inconsistent. Staff have expressed interest in having guidance.

4.55 The Bank has turned to global and regional climate change models to inform decision making on projects and programs. Those models have been useful for awareness raising and context setting, but have often proved less fit for purpose than hoped. They are more suitable for indicating regional temperature-related climate impacts than for quantifying smaller-area precipitation-related impacts. Analyses of long-term climate adaptation options typically confront such a broad range of possible futures that they default to recommending robust, “low-regret” measures.

4.56 There are, however, some areas that require anticipatory climate change adaptation now, because long-run projections are sufficiently clear and because development paths can lock-in to more or less resilient paths. Prominent among these is

the desirability of shaping spatial development patterns to reduce exposure to sea level rise and floods, improve coastal zone management, and make biodiversity more resilient to climate change. However, there are severe political difficulties in regulating land use. Examples are few, and successful examples fewer, but new approaches are emerging.

4.57 There is a potentially important role for the Bank Group in supporting global public goods for ACC. Development of new crop and animal varieties to meet anticipated future conditions (such as drought or inundation) is an important example, because they have a long lead time and can cut short the time to develop locally appropriate varieties. The World Bank indirectly supports CGIAR research and development for this purpose. While the Bank has played a prominent role in protecting global biodiversity in general, it has supported only a handful of projects that conserve wild agrobiodiversity, which could contain genetic material valuable for future adaptation challenges to agriculture.

5. Conclusions and Recommendations

Conclusions

5.1 Climate change makes development more expensive, complicated, and uncertain than was thought. Climate has already changed in ways that impose costs—for instance by making rainfall more variable. Although climate change may open some local opportunities, its global costs will swell in coming decades. People and governments will spend resources defending themselves against risks that include more extreme weather, greater risks to agriculture, coastal inundation, spread of disease vectors, and ecosystem disruption. Some damages will not be preventable, adding to costs. Contingencies for “wild card” outcomes—such as accelerated sea level rise or storm incidence—must increasingly be contemplated, given the unchecked growth in global greenhouse gas emissions and the looming possibility of a 4° C rise in temperature (relative to pre-industrial times) by century’s end.

5.2 Adaptation to climate takes different forms. *First, adapting to today’s climate* (which in part has been shaped by human actions). The gap in crop yields between developed and developing countries, and the disparity in deaths from disasters, underlines the importance of building resilience to today’s climate variability. Adaptation to today’s climate yields immediate benefits and often helps build resilience to ongoing changes. *Second, anticipatory adaptation to transformative changes* such as sea level rise or glacial loss. This might require bearing costs today to keep future options open or to reduce the cost of future catastrophes.

ADDRESSING CURRENT CLIMATE VARIABILITY

5.3 Even the Bank Group’s explicit adaptation efforts have largely been to support activities that address current climate variability. Projects and CASs that address climate adaptation have focused on today’s climate challenges, including disaster risk management, water management, sustainable agriculture, and improving hydromet systems. These efforts address urgent development priorities and yield immediate benefits.

5.4 Similar past efforts—projects that boost resilience to current climate conditions—often appear to be successful, though evidence is spotty. Limited evidence suggests that sustainable land management projects boost yields and incomes. The Productive Safety Net Project in Ethiopia has reduced climate-related food insecurity; similar impacts of a Kenyan drought mitigation and relief project have been harder to demonstrate, though there has been institutional development. Flood control projects have largely achieved physical goals and would be expected

to reduce vulnerability. Recent innovations in financial risk management at the national level have been well received by clients. Results have not yet lived up to expectations for household-level weather index insurance, however. Investments in hydromet systems are plausibly argued to have high economic returns, though rigorous measures are lacking.

5.5 These efforts would mostly be expected to be robust (no-regret) projects that also boost resilience to future climate patterns, regardless of how they unfold. This is particularly true of projects that boost institutional capacity (providing greater capability to deal with an uncertain future), and projects that boost household incomes and assets (buffering them against future climate shocks).

5.6 Would-be no-regret efforts may, however, be unsustainable or maladaptive. Physical and financial sustainability are one hurdle. Mangrove plantations have been torn up when conversion was more attractive to locals than conservation. Drainage systems have clogged and failed from inadequate maintenance. Drought relief systems do not work when funding dries up. Lack of ecological sustainability is another hurdle. Tree planting may end up drawing down aquifers rather than recharging them, as studies suggest has happened in the Loess Plateau. Support for short-term coping could conceivably hinder outmigration from places doomed to inundation or desertification. This suggests the need to root ACV activities in longer-term plans, and to monitor for unexpected maladaptive outcomes.

ADDRESSING TRANSFORMATIVE CHANGE

5.7 The World Bank Group – and others – are only beginning to assess how and when to invest in investments that anticipate transformative change. The Bank Group has invested in analytic studies that look regionally at long-run climate impacts, for instance in the Andes, Zambezi Basin, the Amazon Basin, and the Sundarbans. Some impacts of climate change are not easily predictable. Precipitation, for instance, is highly uncertain in many areas, complicating anticipative adaptation to river basin management. But for other aspects of climate change, such as sea level rise and rises in mean temperature, the broad trends are reasonably well understood though their timing is uncertain.

5.8 Land-use planning makes sense as an adaptation measure that anticipates predictable long-term changes. Over this century, the population of coastal areas and floodplains will swell by billions, increasing overall vulnerability to sea level rise, storm surges, and floods. At the same time, rising temperatures will induce ecosystems to shift. But plant and animals species will be unable to migrate if the way is blocked by intensive agriculture or urban development. These climate-driven trends motivate the use of information, incentives, or regulations to shape spatial

patterns of land use. However, it is politically and operationally difficult and there are few successful examples in Bank Group (or other) experience. Nonetheless, new approaches are underway and should be monitored closely.

BANK GROUP-LEVEL LESSONS

Incorporating Climate Change Risks into the Design and Appraisal of Bank Group Projects

5.9 Operational procedures for identifying and mitigating climate risks are not standardized at the World Bank Group. The new (2012) IFC Performance Standard 1 specifically requires screening for adaptation opportunities. However, neither the IFC nor the World Bank has yet set up systematic procedures for screening projects for climate risks. In two sectors whose long-lived objectives are subject to climate risk—hydropower and protected areas—practice was inconsistent in identifying and mitigating those risks. The lack of guidance on integrating climate risks into project design is a general issue, not restricted to the Bank Group⁴⁷. Without guidance on how to do this, project designers may under- or over-invest in climate risk analysis and in exploring options for resilience.

5.10 Downscaled climate models have so far proven to be of limited operational use for planning at the Bank Group. Global climate modeling is essential for understanding the climate system and has been critical for assessing mitigation policies at the global level. It has been natural to turn to these models for policy and project guidance concerning climate risk. Analytic projects at both IFC and the World Bank have done so, often innovatively. For the most part, these exercises have yielded such a wide span of projections that their authors have defaulted to “no-regret” recommendations that are robust to climate outcomes. This suggests greater emphasis at the Bank Group to methodologies for robust decision making—that is, the choice of policies and projects that are flexible and resilient—relative to climate modeling.

Strategic Guidance, Tracking Results, and Pursuing Effectiveness in Climate Adaptation

5.11 The SFDCC elevated the profile of climate adaptation in country and regional strategies, sparked exploratory analytic work, and witnessed the mobilization of funds for the PPCR. A wide-ranging exploratory approach was appropriate at this initial stage.

5.12 Now, however, the Bank Group lacks a reliable compass to guide future adaptation efforts. Results frameworks under the new Environment Strategy and from the SFDCC close-out are based on indicators that don’t represent the range of adaptation issues, are sometimes only tenuously related to resilience, and when relevant tend to focus on inputs. The World Bank and IFC have developed, in response to an IDA mandate, procedures for tracking projects with climate

adaptation “co-benefits.” The system tracks inputs (spending on projects with climate co-benefits) and intermediate outputs (such as project beneficiaries or hectares with improved agricultural practices), rather than outcomes or impacts. Total spending on climate adaptation-related projects, by this measure, is likely to be used as a measure of adaptation progress for lack of an alternative. But this is an unsatisfactory yardstick because it highlights expenditure rather than results; mixes incommensurable expenditures (policy loans, investment loans, and technical assistance); fails to assess where there are tradeoffs, and where complementarities, with poverty reduction; and ignores the likely adaptive impact of rural roads, female education, urban employment generation, and other interventions that at first glance seem extraneous to climate.

5.13 Project-level monitoring and evaluation often is inadequate, leaving knowledge gaps on the efficacy and cost-effectiveness of interventions. This evaluation could find relatively little gender-related information on impacts. Box 5-1 gives a few examples of the many critical questions whose answers could guide project and portfolio design.

Box 5-1. Some Things We Need to Learn to Promote More Effective and Equitable Adaptation

Poverty reduction, assets, and resilience: As household incomes improve and diversify (from different kinds of projects and policies, in different contexts), to what extent do households become more climate-resilient?

Sustainable land and water management projects: what is their impact, under different conditions, on groundwater recharge, agricultural yields, and carbon storage?

Index-based agricultural insurance: How much does it improve household consumption and resilience?

Ecosystem-based adaptation: Are these interventions (such as mangroves for coastal protection, wetlands for flood mitigation) sustained? If sustained, do they achieve their adaptation goals?

Land use planning and zoning: Are plans being complied with? What is the impact of alternative enforcement and incentive approaches? What are the costs and benefits of different approaches: information provision, permitting, and incentives?

Costs and benefits of flood control and other disaster prevention efforts: What are the costs and benefits of achieving different levels of protection via different means?

Costs and benefits of improved hydromet systems: What are the costs, who benefits, and by how much?

Source: IEG.

THE ROLE OF IFC

5.14 IFC is striving to define its role in climate adaptation. It is a truism that most adaptation will be undertaken by the private sector, yet it has been difficult to identify business and development opportunities. IFC is exploring options in insurance and in stress-tolerant seeds, both of which are potentially large and relevant markets with emerging technologies. A potentially important role for IFC is through indirect channels, such as support for non-farm employment in rural areas. (See Box 2-1.)

NATIONAL-LEVEL LESSONS

5.15 A handful of pioneering countries provide lessons for integrated national planning and implementation of climate adaptation. These include:

- *ACV is perceived as most urgent.* Dealing with current urgent climate risks has generally taken precedence over longer-range ACC.
- *Concurrent planning and execution:* Theoretically, it would make sense to follow a sequence of vulnerability assessment, capacity-building, planning, and implementation. But achieving visible results was necessary to maintain motivation and engagement in the Caribbean and Kiribati, and also provided an opportunity for feedback and learning.
- *The need for focus.* Projects initially tried to cover too broad a range of issues, inefficiently fragmenting efforts and straining limited capacity. It appears to be desirable to focus initially on just one or two sectors or issues.
- *The need for a strong coordinating agency.* This is especially true for smaller countries where adaptation funding may be large relative to the traditional development assistance with which it needs to be meshed.
- *The need for long-term engagement.* Progress has been made in sequences of projects that span a decade or more.

GLOBAL PUBLIC GOODS AND ADAPTATION

5.16 For the most part, adaptation is an activity with local benefits. But there are some global public goods related to adaptation:

- *Climate information* is one. Because weather has no boundaries, a country's hydromet data can help improve its neighbors' weather forecasts, flood warnings, and climate projections. The Bank Group has created a global public good in the form of its Climate Portal. While this provides useful information, it is not clear that the Bank Group is the institution best suited to mount this kind of effort. On the other hand, the Bank Group could play a catalytic role in encouraging the creation and global sharing of hydromet data.

- Another is the *conservation of agricultural biodiversity and the advance development of crops and animals* with characteristics useful for agricultural adaptation in a wide variety of environments. While it is difficult to predict with precision crop needs for a particular spot on Earth, it is very likely that many places will need drought-tolerant and heat-tolerant crops. It is also likely that emergent pests will eventually target existing crop varieties, so the ability to rapidly develop pest-resistant varieties is needed. The Bank Group has played an indirect role in this via its support for the CGIAR.
- *A global system of comprehensive disaster insurance is lacking.* This is a task far beyond the resources of the Bank Group, though it could play a coordinating or convening role in addressing this gap.

Recommendations

GENERAL CONSIDERATIONS

5.17 Climate adaptation will be advanced, to a large degree, by pursuing sustainable development, especially sustainable agriculture, integrated water resource management, and disaster risk reduction. These lines of action, already existent at the Bank Group, provide immediate development benefits and can increase current resilience. They are even more valuable in the face of climate change, because they build up the physical and institutional basis for future resilience. Institutional capacity building is a robust foundation for adaptation to a highly uncertain future.

5.18 Pursuit of sustainable development requires attention to intersectoral and spatial linkages, environmental externalities, social inclusion, and systems for rapidly detecting and diagnosing problems (World Bank 2002). IEG's Environment and Sustainability evaluations have stressed the need for upstream attention to these issues in sectoral strategy and project design.

SPECIFIC RECOMMENDATIONS

5.19 A strategic challenge is to maintain a focus on achieving resilience, while fully mainstreaming adaptation into the practice of development. Many activities can legitimately claim adaptation "co-benefits," though to varying degrees. Some seemingly unrelated interventions may have powerful adaptation benefits—for instance, policies that remove barriers to rural-to-urban migration. An input-based strategy—one based on assumptions about adaptation benefits, rather than actual results—is almost certain to be inefficient. For this reason, IEG's recommendations revolve around building a results framework that provides strategic guidance and enhances learning in this new endeavor.

5.20 Recommendation 1: Develop reference guidelines for incorporating climate risk management into project and program design, appraisal, and implementation. These guidelines are not meant to be rigidly prescriptive but rather to provide guidance on appropriate levels of due diligence for activities of different size, flexibility and longevity, recognizing operational differences between World Bank Group institutions. The guidelines, tailored to project types or sectors, would include relevant risks to be assessed; guidance on available risk assessment tools including their strengths, limitations, and applicability; and options for integrating climate risk considerations into design and implementation. The World Bank Group could use its convening power to assemble climate scientists and industry experts to draft these guidelines, creating a network that would deepen and refine the guidelines over time and might help disseminate them to other interested groups.

5.21 Recommendation 2: Develop and pilot territorial and national-level measures of resilience outcomes and impacts for inclusion in an improved results framework. Current and proposed national-level indicators are only weakly tied to resilience, or measure inputs rather than outcomes. To track progress, the Bank Group should mobilize resources and collaborate with national and international partners to create more sensitive and useful indicators that capture the following dimensions:

- *Institutional measures of adaptive capacity*—including the status of hydromet systems, disaster relief management systems, and agricultural extension systems; and the geographical coverage of vulnerability assessments
- *Household measures of vulnerability and exposure*: based on household surveys that combine information on exposure to climate and other shocks with measures of consumption or food insecurity
- *Biophysical measures of resilience*: such as measures of water use sustainability and of recurrent urban flooding. This could be an area for South-South cooperation, given increasing expertise of developing countries in remote sensing.

Baselines should be established for these indicators, which are intended for ongoing monitoring. These indicators should be refined and improved over time as knowledge of adaptation deepens.

5.22 Recommendation 3: Better assess the costs, benefits, sustainability, and impact of activities with presumed resilience benefits. As sponsor of billions of dollars of activities related to adaptation, the Bank Group is in a unique position to pool knowledge to increase its own and clients' effectiveness in pursuing climate

goals. Box 5-1 lists, as examples, some issues where rapid shared feedback could directly improve effectiveness in pursuing adaptation and development goals. The Bank Group could develop this knowledge in part by piloting approaches to integrating impact evaluation into selected projects with potential adaptation benefits. Experience in the human development sector shows that an offer of funding for impact evaluations finds takers and generates useful knowledge. To be most effective, monitoring protocols should be integrated with project monitoring and evaluation from the start, and should include provisions for comparison or control groups. Rigorous ex ante assessment, along with attention to intermediate outputs, should be used for activities whose impacts are not readily observable in the near term, such as those aimed at reducing vulnerabilities to long-term climate change or to low-probability catastrophic events.

5.23 Recommendation 4: Support countries to improve hydromet services and encourage the use and sharing of hydromet information within and between countries. Prioritize Sub-Saharan Africa and other low-income countries and regions with poor system coverage and low use of services. Support countries to pilot policy reforms and financing models that promote long-term maintenance and a greater array of hydromet products that are accessible and valuable to end users.

5.24 Recommendation 5: Promote attention to anticipatory adaptation to long-run climate change. Specifically,

- i) Where coastal zone management, estuaries and deltas, cities exposed to climate risks, regional agricultural development, and national biodiversity strategies are a focus:
 - a) in the context of country assistance/partnership strategies, signal the need for attention to patterns of spatial development that are resilient to long-run climate change
 - b) in the context of large-scale projects and programs, include assessment of the feasibility, costs, and benefits of alternative policy instruments for shaping long-run climate-resilient patterns of spatial development
- ii) Promote learning on policy instruments for shaping long-run climate-resilient patterns of spatial development, including through small-scale pilot projects, assessment of ongoing projects, and other analytic activities.

5.25 In addition to these recommendations, IEG suggests attention to the following areas.

- Continued support for integrated river basin management, especially for large transboundary basins. Keep in mind that progress may take decades, and support the development of open-source hydrological data and models.
- Support for in situ conservation of agrobiodiversity.
- Working with partners, exploration of means of assuring reliable financing of responses to major disasters.

Appendix A

Sustainable Land and Water Management Projects

PID Country Approval Year	Project name	Reviewed as SLWM portfolio	ICR review outcome	ICR review efficacy	Source	Outcomes SLM	Interventions SLWM	ERR	M&E: baseline	M&E : control groups	M&E: indicators and outcomes connected	Gender-poverty	Sustainability
P056516 China 2001	Water Conservation	All SLWM indicators targeted ⁴⁸	Highly Satisfactory	Not rated ⁴⁹	WB ARD Anchor data	Farmer's incomes increased more than was anticipated at appraisal exceeding PAD projections by 152% to 257%. Increase in yields from baseline, (kilograms per unit of ET; kg/m3) : wheat—82%, corn—183%, rice—70%. Groundwater overdraft was reduced by about 30%.	(a) irrigation and drainage works and on-farm systems, including canal lining, low-pressure pipes, drains, wells, surface irrigation improvements, sprinklers, and micro-irrigation systems; (b) agriculture support and services	PAD— 20.7%, ICR— 24%	yes	yes	yes	Not measured in M&E. Estimates show women participation in WUA 30-40%. Many beneficiaries are poor (poor counties)	There are possible financial risks to the sustainability of project outcomes. Environmental risk—declining precipitation which would constrain water resources still further and could lead to a decline in farmer incomes in some areas.
P067216 India 2001	Karnataka Watershed Development Project	All SLWM indicators targeted	Satisfactory	Substantial	WB ARD Anchor data	Income rise relative to control group of +54% in Phase I and +53% in Phase II (ICR), or +20.4% in Phase I and +24.4% in Phase II according to ISRO ⁵⁰ . Yield: increase averaged across crops and relative to control groups of 24% for Phase I, and 26% for Phase II. Increase in ground water level by 50 ft, 61 ft and 90 ft is observed in the 3 agro-ecological zones (no control group). Groundwater discharge rises from 250 to 325 gallons/hour (no control group). According to ISRO, increase of water yield by 1 to 2.5 inches across treated areas is recorded.	Watershed development: Field operations in 77 sub-watersheds; social, infrastructural and economic activities subprojects; competitive farmer driven research program; dissemination of technologies and information on watershed management, including practical demonstrations	PAD: 16.4%, ICR: 17.7%	yes	yes	yes	Reduced migration. Some undocumented cash requests from large farmers to poor farmers in exchange for the employment. Strengthened women's economic and social status.	Improvements to common lands will in some cases not be sustained because of increasing pressure for fuelwood and grazing resources; risk of reduction of groundwater level: state subsidies to farmers on electricity for bore well operation; financial sustainability of social groups
P064965 Rwanda 2001	Rural Sector Support Project	At least one SLWM indicator is not targeted	Satisfactory	Substantial	WB ARD Anchor data	No targets set for income and biophysical changes. Yield: The quantities and shares of marketed crop output per HH among beneficiary farmers are at least 50% higher than the baseline (includes banana, maize, beans, cassava).	Hillside management (irrigation, terracing), marchlands development	PAD: 19% ICR: 45%	yes	not	not	Gender impact is not reported, no indicators.	Economic, financial, institutional, social risks are low. Environmental risks: it is possible that the cumulative impact of Project-supported activities in combination with activities being financed through other projects and programs could have a combined adverse effect on the environment.
P062714 Yemen 2001	Irrigation Improvement Project	All SLWM indicators targeted	Moderately Satisfactory	Substantial	WB ARD Anchor data	Average yields increased by 50 % for cotton, 49 % for grain sorghum, 53 % for sesame, 62 % for tomatoes and 73 % for onion. Typical small and medium size farms have increased their income in about 45 to 89%. In the three command areas, IIP increased the usable recharge to groundwater by at least 3 million m3/year	spate irrigation, groundwater resources conservation	IRR: PAD— 11.2%, ICR— 16.6%	yes	yes	yes	gender is not an objective, included in post project evaluation by ICR, not in M&E.	Abnormal/unpredictable droughts in southern Yemen, chronic inequitable upland-lowland water/land distribution status in western Yemen, increased productivity per ha (meeting PDO 2) resulting from increased water use per ha
P057847 Armenia 2002	Natural Resources Management and Poverty	At least one SLWM indicator is not targeted	Moderately Satisfactory	Modest	WB ARD Anchor data	No targets set for biophysical changes. Survey: between 2002 and 2008 incomes rose by 21.5% in villages targeted by the project,	Silvo-pastoral agro-forestry systems and biogas production installations. Community pasture management.	PAD: 20%, ICR 13%	not	yes	not	no gender, no indicators for poverty, however project increased income for rural population, most of the poor live	Sustainability of some activities such as the fertilization program for pasture and hay meadows may be low due to high input

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	Reduction Project					compared with 8.5% in non-project villages. Over 30% higher crop yields, 31% higher production (compared to non-project villages) of wool and milk, and increased animal weight for cattle and sheep.	Rehabilitate hay meadows through reseeded, rotational grazing, and restoring degraded pasturelands; construct livestock watering points.					in rural areas	costs.
P043869 Brazil 2002	Santa Catarina Natural Resources Management And Rural Poverty Reduction Project	At least one SLWM indicator is not targeted	Satisfactory	Substantial	WB ARD Anchor data/Watershed	No targets set for biophysical changes. Incomes of the sampled beneficiaries increased on average 30.6% vs. 16.5% for the control group, ranging from 9.7% to 18.5% higher than that of the control group. Net farm income rose an incremental 105%.	Watershed development—creation of ecological corridors, erosion control, sustainable land management practices (including agroforestry)	IRR: PAD—19%, ICR—45%.	yes	yes	yes	Poverty reduced in 64% of 880 microcatchments (91% of target)gender is not an objective, not included in SEA, no M&E.	No risks
P073094 India 2003	Andhra Pradesh Community Forest Management Project	No targets set for income, yield and biophysical indicators changes.	Moderately Satisfactory	Substantial	WB ARD Anchor data	No targets set for income, yield and biophysical indicators changes. No target was set at appraisal for the increase in the proportion of the project area with dense forest cover; but satellite images show that of the 9,210 km2 under the jurisdiction of forest user groups (VSS) participating in the project, 1,728 km2 qualified as dense forest in 2002 rising to 2,149 km2 in 2010.	agroforestry, silvopastoral practices	ERR: PAD—21%, ICR—20%	yes ⁵¹	yes	yes	gender is not an objective, not included in SEA, part of M&E.	The lack of secure legal status for forest user groups and the burgeoning tribal claims to forest land raise doubts about the long-term sustainability of the project's achievements.
P072317 Tunisia 2003	Northwest Mountainous And Forestry Areas Development Project	At least one SLWM indicator is not targeted	Moderately Satisfactory	Modest	WB ARD Anchor data	No targets set for biophysical changes. ICR: average household agricultural income increased by 85% between 2003 and 2009 in constant terms (97% of the target). Crop yields rose 84% for olives and 35% for wheat. Vegetation and forest cover grew from 32% to 38%. 22,251 ha were treated with conservation works and 54,880 ha including rangeland and forestry were improved (14% above the target). There appear to be no soil loss change estimates or dam siltation rate changes	Rehabilitation of small-scale irrigation with water from community wells or existing springs. Sustainable NRM: soil and water conservation works, stonewalls, anti-erosion plantations, small dikes and grass strips; improvement of pasture in range lands and degraded areas; agroforestry development, mainly through the establishment of plantations such as olive and fruit trees with some forage for livestock	ERR: PAD—17%, ICR- 27%	yes	not	yes	Gender was not included in M&E, however, at project completion, women accounted for 17% of CD members, 64% of the training in person/days for off-farm income-generating activities, and 51% of income-generating activities in terms of project numbers.	There are issues of financial sustainability (government commitment) and maintenance.
P074266 Chad 2004	Agricultural Services And Producer Organizations Project	At least one SLWM indicator is not targeted	Moderately Unsatisfactory	Modest	WB ARD Anchor data	No targets set for biophysical indicators changes. Change in yields measured on sample of microprojects—increase in yield for millet/sorghum (60% to baseline) and irrigated rice (77% to baseline). Increase in revenues for beneficiaries of subprojects—indicator was set, but no clear measurement of change (compare to baseline) ⁵² .	Investments in productive infrastructure such as drainage and irrigation; conservation farming support	ERR: PAD—21%, ICR: 3 scenarios —9%, 15%, 19% (depending on financial sustainability) ⁵³ . The ICR review accepted ERR at 9%, as there were no further funding	yes	yes	not	The project empowered many women and enhanced confidence in their abilities, as reflected in the 339 subprojects that were formulated by women's groups and the 146 completed subprojects that were managed by women	High Risk. Lack of financing needed to complete unfinished subprojects. Failure of government to honor fully its commitment to provide additional financing. Uncertain prospects for continued external funding. Loss of experienced project staff. Because of

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								provided to complete sub- projects					
P087707 Ethiopia 2005	Productive Safety Nets Project (APL I)	No targets set for income, yield and biophysical indicators changes.	Satisfactory	Substantial	WB ARD Anchor data	No targets set for income, yield and biophysical indicators changes. Other indicators: share of eligible beneficiaries are confirmed as chronically food insecure; share of beneficiaries participating in public works or in direct support have received grants rather than food; share of kebeles (wards) have developed and approved safety net plans; share of public works sub-projects are assessed as technically sound; etc	elements of SLWM implemented through public works program and through grants for direct support	n/a, however “notwithstanding the higher labor intensity of the project, the ICR reports that it costs “\$1.88 to transfer \$1 in net wage benefit” . Similarly, “...it takes \$2.13 to transfer \$1 of infrastructure benefit to the poor”	yes	yes	yes	gender is an objective, included in SEA, not in M&E. (see details in M&E)	Risk to development outcomes: Financing, technical, and market risks are high.
P066998 Chad 2005	Local Development Program Support Project	No targets set for income, yield and biophysical indicators changes.	Moderately Satisfactory	Substantial	WB ARD Anchor data	No targets set for income, yield and biophysical indicators changes. Key indicators related to the community development.	Matching grants for local development projects	Overall efficiency is rated Modest, calculation of ERR for individual projects was carried out.	not	yes	yes	Subprojects (water supply and sanitation) should have significant impact on women’s chores, but there were no measures for the interventions. Gender is not an objective, included in SEA, not in M&E.	Financial capacity of the central and decentralized public-sector units to perform their duties and provide services initiated by project funding. The economic viability of the subprojects financed under PROADEL-1 remains uncertain, and many subprojects must rely on public-sector financing to carry on their operations. Capacity and availability of trained staff.
P066199 Azerbaijan 2005	Rural Environment Project	No targets set for income, yield and biophysical indicators changes.	Unsatisfactory	Negligible	WB ARD Anchor data	No targets set for income, yield and biophysical indicators changes. Key indicators are: establishment of national parks, number of local entrepreneurs that switched to environmentally sustainable practices	Assist communities living inside or immediately adjacent to the national parks to shift their traditional agricultural and natural resource use practices towards more modern and efficient approaches that place less pressure on natural resources and natural ecosystems.	Not available	yes	yes	yes	Gender is not an objective, not measured. Poverty reduction was implicit in the project.	Risk is high, as both project development objective and global environmental objectives are not achieved
P080829 Brazil 2005	First Programmatic Reform Loan For Environmental Sustainability	No targets set for income, yield and biophysical indicators changes.	Not rated (DPL)	Not rated	WB ARD Anchor data	No targets set for income, yield and biophysical indicators changes. Key indicators	Programmatic approaches through investments and capacity building for ... soil conservation and micro-basin management in the south and southeast, water resource. Budgetary support to Land	n/a (DPL)	no M&E	no M&E	no M&E	not measured	A major risk identified during the preparation of the program—the environmental reform agenda not being carried out adequately—could still be possible. There are several possible causes,

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	(EnvPRL)						Resources Conservation, research and extension						including: (i) the economy remains vulnerable to external shocks and social and political pressure; (ii) a lack of coordination may occur among the key stakeholders; (iii) government agencies may fail to demonstrate sufficient institutional and political capacity to push the reform agenda forward; (iv) some or all partner (sectoral) ministries and agencies may abandon the "mainstreaming" agenda; (v) the Brazilian Legislature may not pass required legislation; (vi) a change in the leadership of individual ministries could lead to a delay in the implementation of the reforms; (vii) a new federal administration may take over in 2007 and fail to implement remaining policy reform steps; or (viii) vested interests
P098093 Ethiopia 2007	Productive Safety Nets APL II	No targets set for income, yield and biophysical indicators changes.	Satisfactory	Substantial	WB ARD Anchor data	No targets set for income, yield and biophysical indicators changes. Indicators concerned about increased food security and reduced vulnerability.	elements of SLWM	Benefit-cost ratio of public works sub-projects in 10 sample watersheds was on average greater than 1. The ratio ranged from 1.8 for soil and water conservation sub-projects, 1.8-2.2 for health projects, and 3.7 for water projects.	yes	yes	yes	gender is not an objective, included in SEA, not in M&E.	Risks to DO are considered moderate due to the increasingly volatile food security environment in the horn of Africa and projections that suggest that there is a need for a permanent food security response mechanism in Ethiopia even for the long-term run.
P034212 Sri Lanka 1998	Mahaweli Restructuring	At least one SLWM indicator is not targeted	Unsatisfactory	Not rated	Watershed	No targets set for biophysical changes. Cropping intensity rose from 135 % to 163 % and water productivity increased by over 30 %. Farm incomes have increased around 25 % compared to an appraisal estimate of 20 %, partly based on diversification into vegetables, grain and fruit crops	Support for planning and implementing activities for SLWM through participatory approaches, dissemination of information, provision of training, technical guidance and mobilization of various land user groups in the basin for expansion of sustainable technologies, awareness and	PAD 14%, ICR: 15%	not ⁵⁴	yes	yes	no gender objectives, no indicators	Sustainability of the development outcomes will depend on the continued government budget support, and skill and staff allocation to continue the program. In this situation, further confirmation is required of the government's ability to continue funding

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							extension. Demonstration activities: land management improvement, control of erosion, reduction of pollution and control of deforestation.						O&M costs of the main systems. Farmers are only contributing a part of the maintenance cost for the tertiary system
P006474 Brazil 1998	3 rd Land management project—Sao Paulo	All SLWM indicators targeted. Great reporting on biophysical changes	Moderately Satisfactory	Modest	Watershed	Income—Non project area: net income increased by 15 %; direct beneficiaries income increased by 45 %. Yield—Non project area: productivity increased by 13 %; direct beneficiaries productivity increased by 45 %. Increase in vegetative soil cover is 12% in 772 micro-catchments (MC) over area of 2.6 m ha; and 25% increase in cover of soils used for annual crops due sharp increase in minimum tillage ⁵⁵ from 100,000 ha to 1.0 m ha, 1998-2007. Est. 120,000 tons topsoil losses stopped annually, saving of 50%; (b) soil conservation tech. adopted in 968 MC; (c) 2,138 erosion gullies stabilized in 258 MC; (d) Riparian re-forestation on 3,783 ha; (e) 1,267 km of riverbanks reforested in 438 MC. Improved soil conditions due to Project-recommended practices: (a) Soil conservation tech. adopted in 970 MC covering 3.3 m. ha; (b) soil structure improved in 258 MC by stabilizing 2,138 gullies; (c) 1,643 km roads repaired, reducing run-off and erosion on bordering lands in 415 MC; (d) soil losses reduced 50% p.a.	i) technology and institutional development to increase awareness of natural resource management issues and facilitate participatory management of land resources; (ii) adaptive agricultural research to provide technical solutions for soil conservation, integrated pest management, disposal of residual inputs and crop diversification; (iii) incentive program for sustainable natural resource management and conservation through community awareness building, the provision of grants for demonstration plots and greater enforcement of land legislation; (iv) erosion control along rural roads; (v) training of extension agents and beneficiaries	PAD: 20%; ICR: 27%	yes	yes	yes	There was no explicit focus on gender. The Project's innovative social features reflected the poverty focus of the CAS, acknowledgment that zones of highest erosion and degradation tended to also concentrations of small, poor farmers.	Project interventions will mitigate risks to the sustainability
P056216 China 1999	Loess Plateau watershed rehabilitation project	All SLWM indicators targeted	Highly Satisfactory	High	Watershed	Income is 58% higher than in non-project areas. In 1999-2004, the average annual per capita incomes of project households increased from RMB783 to RMB1,624 (134 % of the appraisal). Not yield but production per capita increase was measured: 65% to baseline. The accumulate sediment retention (total 53.4 million tons or 103 % of the appraisal).	(a) the construction of terraces to create high-yielding leveled farmland for field crops and orchards on slopes of less than 20 degrees, thereby permitting the replacement of some of the areas devoted to crops on erodible slopelands; (b) the protection of slopelands from grazing and partial planting with a range of trees, shrubs and grasses to reduce soil loss and to produce fuel, timber and fodder; and (c) the provision of support to farmers in a range of income-generating farming activities, including livestock development in pens, dairy cattle, fruit and nut trees, and irrigated agricultural production, to provide sustainable income alternatives to destructive slopeland grazing.	PAD 20.9%; ICR: 18-21%	yes	yes	yes	No gender objectives, no indicators. Employment of women and their labor productivity has particularly benefited from new or expanded livestock activities.	Project interventions will mitigate risks to the sustainability

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P005519 Morocco 1999	Lakhdar watershed management pilot	At least one SLWM indicator is not targeted	Satisfactory	Substantial	Watershed	Yield, income and biophysical indicators were not measured. ICR estimates of vegetative cover on sylvopastoral land in the project area indicate an increase by 4% in the upper part of the watershed, by 16% in the middle part where gullies and ravines are located, and by 11% in the lower part. ⁵⁶	Interventions: erosion control, sylvopastoral land improvement, forestry management, fruit-tree plantations, rehabilitation of small scale irrigation schemes, technical support to farmers, training of technicians, and, participatory monitoring of the impact of erosion control works. Social infrastructure- small rural roads, water supply systems Institutional building	PAD: 17%. ICR estimate: 21% ⁵⁷	not	not	not	Gender: efforts for women employment and involvement were not successful. Produced carpets did not find market, women's voices were not taken into account for community development projects. Poverty impact is implicit as most of the farmers are poor.	Projects need to take gender patterns of work into account There is a risk that, once the project is closed, the implementing agencies won't see the need to maintain the PMU. At the central level, because institutions are built along vertical sector lines, top management may not appreciate all the benefits of this approach. Horizontal cross-sector cooperation and decentralization reduce the power of (vertical) sector ministries whose leadership may resist. For public investments there is a real risk that Government and/or rural communes will not be able to continue funding their major maintenance and repairs after the project life as their budgets may not allow it.
P041264 India 1999	Integrated watershed development project I	At least one SLWM indicator is not targeted	Satisfactory PPAR: Moderately Unsatisfactory (downgraded by PPAR)	Not rated	Watershed	ICR estimate: rainfed farms realized 94% more net benefits/income and irrigated farms realized 152% more net benefits than control areas as a result of project interventions. Yield: Rainfed wheat increase (average between states) +50% ⁵⁸ , maize + 18% ⁵⁹ . In different states the variation of yield increase was for wheat: 30% to 90%, for maize: 8% to 45%. Biophysical indicators: Run-off dropped (5 to 18% in different states), hydrological regeneration (soil water regimes, ground water augmentation).	Watershed Protection and Development: (a) watershed treatments; (b) fodder and livestock development; (c) rural infrastructure development. Institutional Strengthening: policy reforms, studies and human resource development, beneficiary capacity building income generating activities for women	PAD 17%, ICR: 15%	yes	yes	yes	Income generating activities for women were planned at the appraisal. The gender composition in the Executive Committees is encouraging as women membership is ranging between 25-40%	Risk to Development Outcome is rated Significant. The absence of linkage between the Village Development Committees and local government (the Gram Panchayat, or GP) is the main risk. Former members of the implementation units in the five states covered by the project told IEG that many of the Village Development Committees have disappeared and watershed treatment works have not been maintained. This is consistent with findings from studies of other watershed development projects carried out in the Shivaliks.
P059305 Lao People's Democratic Republic 1999	District Upland Development And Conservation Project	No targets set for income, yield and biophysical indicators changes.	Moderately Satisfactory	Not rated	Watershed	No targets set for income, yields and biophysical changes. The adoption of more intensified agricultural practices by upland farmers in pilot village: Achievement—Between the baseline survey (2000) and 2002 there is evidence of a modest adoption of intensified agricultural practices. ⁶⁰	Information and simple technologies to intensify production of paddy rice and home garden food crops, as to domesticate non-timber forest products. Conservation Support and Awareness Component. The participatory appraisals would lead to identification and formation of farmer interest groups and selection of farmers for initial demonstration trials.	Not available	yes	yes	yes	no gender objectives, no indicators	Sustainability of the conservational farming activities will require additional financing
P049665 China 1999	Anning Valley Agricultural Development Project	At least one SLWM indicator is not targeted	Satisfactory	Substantial	Watershed	No targets set for biophysical changes. Per capita, rural, increased compare to baseline +227% (from RMB 880 baseline to RBM 2884 -RMB 3960). Yield: Rice increases +5% compare to target (to 9.0 tons/ha compared	Water Resources Development: water supply for irrigation needs, domestic and industrial use, dam and canals for irrigation and small hydropower stations Crop development: Increasing	PAD 25%, ICR: 27%	yes	yes	yes	Poverty incidents: reduced from 33% to 13%. Women: 40 % of the participants in agricultural technology training and extension sessions, women carried out roughly 80 % of activities in small livestock,	Project interventions will mitigate risks to the sustainability

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						with the 8.5 tons appraisal target); and, for wheat + 50% (to 6.0 tons compared with the targeted 4.0 tons/ha).	food production, focusing on the main staple food grains, potatoes and vegetables, by: land improvement; multiplication of improved seed varieties; extension service, farmer and staff training, and research. Orchard Development: high-quality fruit trees and reducing soil erosion on sloping land, by: investing in nurseries; establishment of new orchards and rehabilitation of existing ones; post-harvesting facilities; and training, research and extension.					vegetable and silk cocoon production.	
P084742 China 2006	Irrigated agriculture intensification loan3	All SLWM indicators targeted	Not yet rated. ICR draft	Not yet rated. ICR draft	Watershed	Draft ICR data were used. Compared to baseline, grain crop yields in the project areas increased by 27% and output increased by 75%. Under the water saving component, water use at completion dropped to 3809 m ³ /ha or 60% of the appraisal target of 6,306 m ³ /ha, compared to baseline use of 6892 m ³ /ha; water productivity rose from the baseline of 1.03 kg/ m ³ to 1.55 kg/ m ³ at completion, which exceed the appraisal target.	Assessment of adaptation options: Impact assessment of climate change in 3-H Basin and project area (assessment of hydrology and potential crop production, prioritization and selection of adaptation measures and demonstration areas). Water resources management measures, including the development of catchments to enhance rainfall storage capacity and reduce water logging threats, well-based irrigation with reinforced prevention and resistance to drought and advanced field “real” water-saving irrigation technologies and works; adaptation-oriented farming practices, including adjustment of farming patterns to reduce water consumption, and combining drainage with irrigation to avoid soil deterioration; water-savings-oriented farming technologies, including development of drought resistant varieties, “seeded in water” practices, membrane and biological water conservation to deal with water scarcity, and land and ecosystem rehabilitation and amelioration; and	PAD 23.7%, ICR: 25.3%	yes	yes	yes	To promote women’s participation, the Grant (Trust Fund) was provided for “gender mainstreaming” (more in M&E section). In terms of poverty impact, low income groups had a slightly higher percent gain in income compared to medium and high income groups.	(Financial risks related to water fees—they are still too low to cover all O&M costs). From ICR: No risks that may threaten the project’s development outcome are known or likely in the foreseeable future.

Appendix B

Adaptation-Related Indicators and Achievements under the SFDCC

SFDCC Objec- tive	Action	Products/processes/indicators	Time line	Substance
Action Area 1: Support Climate Action in Country-led Development Processes	Enhance cooperation with development partners to facilitate global action	<ul style="list-style-type: none"> • Collaboration with the UN and its agencies on a coordinated approach to climate change, particularly financing , capacity building and monitoring 	FY09-11	Joint WB-UNDP website created with inventory of climate finance options.
		<ul style="list-style-type: none"> • Joint implementation of CIFs with other MDBs 	FY09-10	Achieved
		<ul style="list-style-type: none"> • New partnerships established, particularly to facilitate the work on technology and adaptation 	FY09-10	Management cites partnerships with two universities on climate data sharing, and a training workshop in Mexico City.
	Support climate actions by operational strategies	<ul style="list-style-type: none"> • Actions to strengthen climate resilience are supported by several CASs, with an estimated demand by at least 10 countries with high vulnerability to climate risks 	FY09-11	Completed.; of 56 Country Assistance Strategies and Country Partnership Strategies approved over FY09-11, 33 were identified by the Environment sector as containing some content related to increased resilience, and validated by IEG; 21 had significant provisions. Of the 33 CASes that contained any reference to climate resilience, 24 cases demonstrated a significant change in Bank policy relative to previous practice in that country
		<ul style="list-style-type: none"> • Support to climate actions included in business strategies for WB regions, MIGA and IFC 	FY09	Achieved for the WB AFR: Making Development Climate Resilient: A World Bank Strategy for Sub-Saharan Africa. Disaster risk reduction should be an integrated agenda, Adaptation is Development, Mitigation should include provision of energy access, including clean coal, Scaling-up finances is necessary. EAP earlier approved Regional Strategy (FY2008)– Securing the Future: Supporting shared and sustainable growth in the East Asian and Pacific countries and beyond – included at least 1 climate related Pillar: <i>Strengthening support to global</i>

Support climate actions
by operational
strategies
(continued)

public goods and regional cooperation — supports efforts in mitigation and adaptation.

Regional climate change flagship report (FY2010) focuses on low carbon and clean energy; adaptation is in countries context.

ECA: *Climate Change Actions for Sustainable Growth* — is one of the 3 pillars of the 2012 ECA Strategy, identifies 3 lines: adaptation, EE, and RE. Regional flagship report *Adapting to Climate Change in Eastern Europe and Central Asia* presents adaptation options for the region.

LCR: climate/climate change was a pillar pre-SFDCC period (FY08 Regional Flagship; Low Carbon Study (Brazil, Mexico); Clean Energy AAA)

MENA Regional Business Strategy to Address Climate Change is not yet approved. Issue Paper was prepared in 2007, to identify main impacts and option for adaptation: *Climate Change in the Middle East and North Africa: Impacts and Adaptation Option*

SAR: Climate (vulnerability and change) is included in the regional strategy (not as a stand-alone pillar, but a part of *Regional Cooperation* pillar).

Not achieved for IFC in adaptation: IFC Road Maps: the discussions on adaption strategy in these documents were limited, though improving over time.

• Urban Strategy update includes consideration of climate risks and support to climate actions

FY09

Achieved: covers: greenhouse gas emissions in cities, climate change hazards, energy efficient cities

• Energy Sector Strategy includes consideration of climate risks and support to climate actions

FY10

Not completed (Strategy is not yet adopted)

Action in
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APPENDIX B

Action Area 1: Support Climate Action in Country-led Development Processes (continued)		• Social Development Strategy update includes consideration of climate risks and support to climate actions	FY10	Achieved. Mid Cycle Implementation Progress Report (MCIPR) – identifies main issues and pillars. Resilience is a fourth pillar, means resilience to global situation, climate change, disasters, and conflict/violence
		• <i>Environment Strategy update includes consideration of climate risks and support to climate actions (indicator proposed by progress report)</i>	FY11	Achieved.
		• ICT Strategy update includes consideration of climate risks and support to climate actions	FY11	Not completed. The new ICT strategy is at consultation stage.
	Support climate actions in lending programs	• A plan for strengthening synergies between support to disaster risk management and support to adaptation developed and implementation started	FY09–10	Adaptation is a pillar of the GFDRR business program (climate risk in development planning). IEG found a modest impact of GFDRR in mainstreaming disaster risk reduction in CASEs. However, no specific “plan for strengthening synergies” is evident.
		• Screening of relevant projects for climate risks and sector-wide vulnerability assessments introduced	FY09	Not achieved. Prescreening tool based on river basins (Strzepek, McCluskey and others 2011) was developed but “is not intended for use at the project level.”
		- starting with hydropower projects		
		- extending to other vulnerable sectors within regional context	FY10-11	Not achieved.
		- <i>methodology for city-wide climate vulnerability assessment developed (indicator proposed by progress report)</i>	FY11	Achieved. The Urban Risk Assessment framework is developed
	Develop an outcome-based results framework	• A set of definitions and outcomes developed by the World Bank Group	FY10	Results framework, adopted FY12, is largely not outcome-based.
		• Improved climate-related portfolio tracking	FY10	Tagging system developed. See text for a critical review.

Action Area 2: Mobilize Additional Concessional and Innovative Finance	Increase access to additional finance to cover higher costs and risks	• Maintained or increased IDA replenishment levels, and improved tracking of ODA to climate-related actions, mitigation and adaptation (with DAC)	FY11	Achieved
		• Climate Investment Funds operational with a target of \$6 billion	FY09	Achieved
		• Country-level activities start under FIP and SREP; implementation of strategic programs starts under PPCR.	FY11	Achieved.
		• Increased leverage of GEF funds through programmatic approaches	FY09–11	Achieved. Leverage needs to be discussed
		• Guidelines to help access various financing instruments and reduce transaction costs prepared	FY09	Achieved As a part of reported earlier achievement under Climate Finance Knowledge Platform: one-stop knowledge virtual centre on climate finance, offering practitioners detailed and up to date information for better decision making
		• Guidelines extended to a broader range of instruments	FY11	Not achieved. Referred guidelines are not developed, indicator is not clear.
Action Area 3: Facilitate the Development of Market-based Financing Mechanisms	Increase access to market products, including for REDD and adaptation			
		• Access to climate risk management products and reinsurance markets increased	FY10	Achieved
Leverage Private	Increase leveraging of private investments			

APPENDIX B

Action Area 5: Support Accelerated Development and Deployment of New Technologies	Develop new partnerships and approaches for technology cooperation	• Subnational level application of financial tools is tested for projects with climate co-benefits – at least 3 in a pilot phase (further estimates to be provided if/when post-pilot stage approved)	FY09	Achieved
		• Work by CGIAR on climate-resilient agriculture technologies scaled up (measured by increase in funding)	FY09–11	CGIAR attention to climate change increased; the World Bank continued to make fungible contributions to the CGIAR.
Action Area 6: Step Up Policy Research, Knowledge, and Capacity Building	Advance knowledge on climate and development	• The global economics of adaptation study completed and improved the knowledge of adaptation processes, costs, and benefits	FY10	Achieved
		• WDR2010 on climate change launched and contributed to global knowledge and dialogue	FY10	Achieved
		• Monitoring on global climate action improved, through joint effort with the UN and OECD, and reported in flagship World Bank Group knowledge products (such as WDI)	FY10	Website on climate finance options was launched.
	Develop and test new analytical tools	• Good practice guidelines to help relevant operations account for social and gender dimensions of climate change prepared	FY09	Achieved. Social resilience and climate change: Operational Toolkit. Gender tool in the toolkit refers to existing gender and climate change tools developed by UNDP and IUCN ⁶¹
		• Toolkits and decision-making guides for adaptation / mitigation to climate change in agriculture and water sectors developed and applied	FY09–10	Partially achieved: toolkits developed and applied only in water sector
	Capacity building	• Country-level expertise and capacity to manage development- climate linkages and access to additional finance strengthened	FY09–11	No substantial adaptation-related capacity building reported

• Potential of existing programs reviewed and enhanced, and a coordinated program with UN agencies developed	FY09	Repeated reference is made to the Climate Change Knowledge Platform.
• Wide coverage of staff and managers by specialized training programs on development and climate change; climate issues included in other training programs, as appropriate	FY 09-11	Adaptation-related training for staff and managers was not reported.
• Number of training sessions held in client countries (and staff covered)	FY09-11	31 training sessions reported; adaptation-related share of not reported.
• Enhanced skill mix to support climate actions (in client countries)	FY10	Achieved

Appendix C

Results Indicators

Table C.1. Resilience Indicators Proposed under the SFDCC Close-Out Report

Indicator	Tier	Sensitivity and relevance	Measurability	Feasibility	Timeliness	Disaggregability	Generality
Population below \$1.25/day	Country context	Medium; poverty is related to sensitivity to climate shocks	High	High	Low; latest is 2005	Low in practice, high in principle	High
GDP per capita	Country context	Medium	High	High	High	Low to medium	High
Access to improved water source (percent of population)	Country context	Low to medium; does not measure whether water quality or quantity is sensitive to CV; little relevance to CC	High, given WDI definition	High; from WDI	Medium, latest available is 2008	Low in practice, high in principle	High
Cereal yield	Country context	Medium to high; for Sub-Saharan Africa it is likely to be closely related; elsewhere could reflect maladaptive overuse of water	High, given WDI definition	High; from WDI	Medium, latest available is 2009	Low	Medium; most applicable to rainfed drylands
Countries with disaster reduction and recovery programs addressing 5 HFA priority areas	Country context (Hyogo Framework for Action)	High	High	High	High	n/a	High
Proportion of roads paved	Country context	Low to medium; paved roads more resistant to storm, but unpaved roads promote rural resilience in	High	Medium, many countries do not report	low	Low in practice, high in principle	Medium, not all places have climate-sensitive roads

Indicator	Tier	Sensitivity and relevance	Measurability	Feasibility	Timeliness	Disaggregability	Generality
		times of drought, so there is a tradeoff between more roads versus higher proportion paved.					
Protected terrestrial areas as a proportion of surface area	Country context	Low; some protected areas may promote resilience (for example, watershed protection), but many have no functional relation and are themselves vulnerable	High	High	High	High	High
Number of countries with National Adaptation Plans	Country context	High	High	High	High		
Percentage of hydropower projects supported by the Bank Group that address river basin planning and water use management in planning and design	Project	Low to medium; hydropower projects, especially from IFC, may not be the appropriate channel for approaching river basin management issues	Low; how to define "address"	High	High	Not applicable	Medium
Number of countries supported by the Bank Group on natural disaster management and response	Project	High	Low; what constitutes "supported"	High	High	Medium	High

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RESULTS INDICATORS

Indicator	Tier	Sensitivity and relevance	Measurability	Feasibility	Timeliness	Disaggregability	Generality
Area provided with improved irrigation and drainage services and increased climate resilience (ha)	Project	High, if unsustainable irrigation is excluded	Low; needs an operational definition of "increased climate resilience"	Indeterminate	Indeterminate	Low	Medium
Number of beneficiaries who have adopted improved technologies in agriculture operations that incorporate climate resilience	Project	Medium; does not reflect degree of resilience	Low; needs an operational definition of "incorporates climate resilience"	Indeterminate	Indeterminate	High	High

Definition of criteria:

Sensitivity and relevance: Is it closely related to a particular aspect of resilience?

Measurability: Is it precisely defined and operationalizable?

Feasibility: Can it be measured at reasonable cost, with low demands on capacity?

Timeliness: Can it be measured, on a regular basis, with little lag?

Applicability: How broad a set of countries or issues does it pertain to?

Disaggregability: Where relevant, can the indicator distinguish impacts on, or capacity of, women and other groups of concern?

Note: CC= climate change, CV=climate variability, WDI = World Development Indicators

Source: IEG.

Table C.2. Suggested Alternative Indicators for Measuring Resilience

Indicator	Country or project level	Relevance	Measurability	Feasibility	Timeliness	Disaggregability	Generality
Meteorological stations reporting at least 90% of SYNOP data to WMO per 10,000 square kilometers	Country; or project contributions to this indicators	High; a basic element of capacity and information for CV and CC	High; uses WMO definitions and criteria	High; monitored by WMO	High; reported semiannually	Not applicable	High
Existence of vulnerability assessments for chief CV threats	Country; or project contributions to these indicators	High; basic foundation for disaster risk management	Potentially high; essential components of assessment need to be defined, along with	High	High	Not applicable	High
Innovations adopted per farmer due to extension services	Country; or project contributions	High; a measure of capacity to adapt to changing conditions	Medium; requires clear definition of "innovation"	Traditionally low; see digitalgreen.org for a working example of real-time, low cost monitoring in India	Potentially high	High	High
Proportion of country with Consumptive use of water > 80% of sustainably available water	Country; or project impacts on consumptive use	High; a measure of resilience to water shocks	High	Medium: requires a combination of modeling and remote sensing; Innovations in evapotranspiration monitoring	Potentially high if automated	Medium: could disaggregate by province or district	High

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RESULTS INDICATORS

Indicator	Country or project level	Relevance	Measurability	Feasibility	Timeliness	Disaggregability	Generality
Changes in water storage (including groundwater depletion)	Country	High; another measure of resilience to water shocks	High	Semi-experimental; has been accomplished at the global level through modeling and at subnational level via use of GRACE satellites	High	Low: some geographical disaggregation is possible	Medium; not an issue for some high water availability countries
Reservoir capacity/capita	Country, or project level contribution to country level	High	High	High; reported by AQUASTAT	Low to medium	Low	Medium; not an issue for some high water availability countries
Proportion of population experiencing specified degrees of food insecurity	Country, or project contribution to reductions in the proportion	Medium, since it reflects severity of shock as well as degree of resilience; progress in resilience is tracked by relating this measure to the degree of climate stress	High; operational definitions exist	Medium; demonstrated regionally (by FEWSNET, IFPRI survey of Ethiopia PSN, among others)	High; can be reported monthly	High if based on surveys	Medium
Proportion of population experiencing flooding	Country; or project contribution to reductions in the proportion	Medium, since it reflect severity of shock as well as degree of resilience; progress in resilience is tracked by relating this measure to the degree of climate stress	Medium; needs definition of "experiencing flood"	High; could be accomplished via remote sensing; however remote sensing has difficulty with mountain floods	High if based on remote sensing	High if based on surveys	High

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RESULTS INDICATORS

Indicator	Country or project level	Relevance	Measurability	Feasibility	Timeliness	Disaggregability	Generality
Household mean and minimum consumption over time	Country; or project contribution to reductions in the proportion	Medium; progress in climate resilience is tracked by relating this measure to the degree of climate stress; captures resilience	High	Difficult but with potentially high payoff; requires investment in household panel surveys, possibly using new technologies	Potentially high	High	High

Appendix D

Drought Mitigation Projects, Ethiopia and Kenya

Kenya Arid Lands Management Project⁶²

Since 1996, the World Bank has funded a sequence of projects under the Arid Lands Resource Management Project (ALRMP).⁶³ Phase 1 (1996–2003) was motivated by vulnerability and resource degradation resulting from overstocking of cattle and repeated droughts. An IEG evaluation found that the project succeeded in improving drought monitoring and response. Time between reported stress and response was reduced to 2 to 3 weeks, and interventions saved lives and reduced livestock mortality. Better markets for pastoralists reduced overgrazing near water points, allowing herders to sell stock in good condition. Benefit/cost ratios for livestock activities were estimated to be between 2 and 8. ALRMP II (2003–11) continued the program, with increased coverage into some semi-arid areas.

The experiences and lessons from ALRMP have been informed development of the national drought management system, starting at the district level. An important focus of ALRMP was the development of drought preparedness and contingency plans at the district level, complemented in some cases by plans for natural resource management. Effective drought management and response involves a range of interrelated tasks of assembling information on climate and vulnerability to food insecurity, training staff to create, use, and apply this information, and fostering capacity for policy-making and implementation. District Steering Groups (DSGs) have been central in enhancing drought management actions, including improving drought coordination, reducing duplications, and improving response at the district level. In addition, ALRMP has had major influence on national policy and development agendas in the arid and semiarid lands.⁶⁴ The experiences and lessons from ALRMP have informed national drought management policy and response through the creation of a National Drought Management Authority (NDMA) and Drought Contingency Fund. And it has coordinated with other agencies, such as FEWSNET, in developing and disseminating drought management and early warning information

Against these institutional successes, a forensic audit by the Bank's Integrity Vice Presidency found evidence of serious shortcomings suggestive of systemic corruption. The audit found that 29 percent of sampled transactions were

questionable. The extent of such fiduciary issues remains a major challenge to addressing persistent food security and reducing livelihood vulnerability in Kenya.

In connection with the audit, the project was shut down prematurely, raising questions of sustainability. While ALRMP's institutional advances appear to be robust, the abrupt cutoff in funding hampered responses to the 2010-11 drought. Agency responses suggested that the drought response in 2010-11 was less effective and timely than those in previous years, in part, due to the absence of funding for the Drought Contingency Plan. Consequently, critical drought mitigation interventions, such as emergency livestock marketing, were either late or not implemented at all.

The International Livestock Research Institute (ILRI) assessed the impact of ALRMP II based on extensive surveys and statistical analysis (Johnson and Wambile 2011). It found significant institutional contributions, but only weak evidence of impacts on livelihoods and resilience, as follows:

- *Number of people needing food aid:* The analysis found a small but negative and statistically significant correlation between cumulative ALRMP expenditure and the percent of people needing food aid in the arid districts. The correlation between ALRMP II expenditure and the percent of people needing food aid was not significant in semiarid districts.⁶⁵
- *Emergency response to drought:* The time that agencies took between becoming aware of an emergency and responding dropped by 1.5 weeks (16 percent) during the time that ALRMP was operational.
- *Impacts on child nutritional status:* Using a very large sample, one analysis found a modest increase in nutritional status in areas benefiting from ALRMP.⁶⁶ No gender analysis was performed.
- *Access to social services:* There was no significant difference between intervened and control areas.
- *Institutional impact:* Thirty-five percent of community representatives report more empowerment. Various respondents reported significant contributions to national policy development.

Ethiopia Productive Safety Nets Program

The Ethiopia PSNP is now in its third phase. The program was designed to transform Ethiopia's safety net system externally and internally. The starting point was a reactive system, funded by emergency appeals to donors, that used food transfers for drought relief. The system transitioned to a multiyear prefinanced system that set aside contingency funds for years of severe drought. Drought relief

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DROUGHT PROJECTS

took the form of payments for labor on community-identified public works intended to build up resilience to future droughts. Additional funds were provided as direct support to especially vulnerable households.

The PSNP has been the subject of rigorous impact evaluation by the International Food Policy Research Institute (IFPRI), with a panel of households surveyed every two years. Studies (Berhane, Hoddinott and others 2011a) found that participants in the public works component of the PSNP experienced 1.5 fewer food-insecure months than nonparticipants in areas not affected by drought.⁶⁷ In drought-affected areas, the reduction was 0.93 months. (The evaluation was not able to detect an impact on caloric intake, perhaps for technical reasons.) In both areas, participation in the public works component increased animal holdings by 0.4 tropical livestock units. Direct support payments to households unable to supply labor, also reduced food insecurity. The evaluation found that public works participants who also received extension and credit services were more likely to invest in stone terracing (a soil conservation measure) and fertilizer, boosting their yields.

IFPRI also evaluated the implementation and institutional performance of the system. The system is improving over time, but there are shortcomings. Budgets are not adequate to meet the needs of all eligible people, so rationing takes place. The early warning system is improving, but most districts are not able to use it for effective contingency planning. The payment cycle takes 39 days on average, with wide variations between districts. Women are well represented on subdistrict committees, but work allocation does not take account of women's greater domestic time obligations or differentiate on the basis of ability to perform heavy physical labor. Implementation challenges have been greatest in lowland regions populated by pastoralists (Berhane, Hoddinott and others 2011b).

Appendix E

Roads

Roads are vulnerable to climate risks, and these risks are likely to increase due to climate change. The main threats come through an increase in extreme rainfall and storm events (which can cause flooding or landslides that damage or destroy road sections) and from sea level rise (which will worsen damage from storm surge and coastal flooding and may even eventually lead to inundation).⁶⁸ The largest impacts will be for roads in upland areas with steep topography, and for coastal roads in areas vulnerable to storm surge. For example, a World Bank analysis of the impact on climate change on roads in Ethiopia found that in the absence of adaptive measures, costs to road users from climate events could double by 2050 (COWI 2010).

Normative Considerations

Managing climate risks has long been part of best practice in road design. Damage from storms and flooding can be reduced through physical measures (including both structural drainage and protective measures, and bio-engineering options such as use of vegetation for slope stabilization or run-off management) and through improved capacity (for road maintenance, land management, warning systems, and emergency response systems). It is difficult to make broad claims about the cost-effectiveness of particular measures, because the impacts vary widely depending on topography, climate, and other factors.

Design features of roads have different lifetimes, hence different sensitivities to climate variability versus climate change. Short-lifetime features should be designed with current climate variability in mind. For instance, pavement standards or embankment height can be readjusted to current temperature, flood, and traffic conditions when a road segment is rehabilitated – typically every 20 years. Within this timeframe, climate change is too slow to affect pavement standards.⁶⁹ Longer-lived and more inflexible are drains, culverts, and bridges, so these require more consideration of climate change impacts during their operating lifetime. Longest-lived of all is the decision on routing, which can affect spatial development patterns (and exposure to climate risk) for centuries. (See Box 4-2. in the main text.)

Adaptive management and targeted improvements may be more efficient than immediate or blanket techniques. An analysis of road options in Mozambique under climate change (Arndt and others 2011) compares and contrasts a strategy of adaptive management – gradually rehabilitating existing roads and building new

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ROADS

roads to higher standards as climates change—to a strategy of immediate and general upgrading, and find that the adaptive option is more cost-effective. The study also finds that targeted upgrading for particular flood-prone areas is more efficient than an across-the-board increase in standards.

EXAMPLES IN PRACTICE

Two recent Bank projects highlight some examples of how climate resilience has been explicitly considered in road project design.⁷⁰ A climate resilient road project in Timor-Leste emphasized the need for sufficient drainage, noting that 92 percent of roads were in poor or very poor condition, largely due to landslides, floods, and insufficient maintenance and drainage capacity (World Bank 2011b). A climate change impact assessment study found that there would likely be fewer but more extreme rainfall events, which would increase demands on already insufficient road infrastructure (Cardno Acil 2009). The primary component of the project thus supported urgent road repairs followed by a program of road improvement involving construction of slope stabilization structures and drainage structures. Recognizing that it is not optimal to try to prevent all road damage, the project design included performance-based contracts for long-term road maintenance, and supported design and pilot implementation of emergency response systems to undertake rapid repairs after a storm. A road rehabilitation project in Kiribati focuses on rehabilitating the main road on Tarawa, but also used a coastal assessment from the Bank's Kiribati Adaptation Project II to identify areas vulnerable to erosion where coastal protection structures would be required. In both cases, the primary concern is dealing with shocks due to current climate variability rather than future climate change.

Appendix F

Analytic Work on Climate Adaptation

F1. The Economics of Adaptation to Climate Change

A World Bank study on the economics of adaptation to climate change (World Bank 2010) attempts to estimate the size of these costs at a global level. This is a herculean task, considering the vast uncertainties in the effects of climate change and the difficulties in quantifying the benefits and costs of adaptation actions. The study estimates that a world that experiences warming of 2 degrees Celsius by 2050 would require adaptive actions costing \$70 billion to \$100 billion per year.

The study's approach is to select adaptation actions that will counteract the expected impacts of climate change on welfare in each sector analyzed – infrastructure, coastal zones, water supply and flood protection, agriculture, fisheries, human health, and forestry and ecosystem services. The approach has several weaknesses. The calculation considers only “hard” investments and not institutional or policy changes, and considers only public adaptation actions, and not private adaptation. The calculation assumes that planners have perfect foresight, and so can select the optimal actions to adapt to a wetter or drier scenario. And the calculation cannot incorporate cross-sectoral substitution; it requires that welfare in each sector be restored, even though an optimal response might encourage a shift out of sectors that are hit hard in particular countries.

Despite these challenges, the approach highlights a critical point; what matters is improving welfare, not directly trying to counteract the specific impacts on climate change. The study concludes that general development is perhaps the best form of adaptation; that current adaptation actions should focus on “low regret” options that reduce adaptation deficits; and that investment projects that are highly vulnerable to uncertainty about the future climate state should be delayed until more information is available.

But the inherent methodological challenges faced by the researchers suggest that while this study was worthwhile to provide an order of magnitude estimate, the gains from continuing to try to produce further estimates at the global level are likely to be modest. Future Bank support for cost and vulnerability estimates is likely to be more effective at the national or subnational level (as in the case studies performed under the EACC study).

F2. Methodological Weaknesses in Estimates of the Returns to Hydromet investment

Studies that estimate the economic returns to hydromet investments often contain a number of methodological weaknesses:

- They ignore benefits from reductions in deaths or injuries. It would be possible to assess these benefits using existing willingness-to-pay for mortality reductions in health service, traffic safety, etc.
- They usually consider only benefits from reduced damages, without considering benefits from reduced business disruption, or benefits from opportunities that may become available given reliable weather forecasts.
- Studies often do not consider the full costs involved. They attribute the full benefits of reduced disaster damage to the warning system (which sometimes seems to consist of just the computer system, model, and a handful of staff) without considering any of the complementary investments (such as cyclone shelters, communication systems, etc.) that may be required in order for those benefits to be realized.
- Some studies do not discount benefits when calculating benefit-cost ratios: they compare an upfront investment cost to the nominal stream of benefits that come in a stream over time.
- There is dramatic variation in the time horizon; studies might assume that annual benefits will occur for as little as 5 years or as much as 19. This makes cross-study comparison difficult.
- Some estimates include benefits that could not reasonably be attributed to the warning system, like the reduction in damage to houses from windblown trees from better maintenance of trees (unless the trees are maintained only once the warning is received).
- Many key parameters are based on guesses or assumptions. They sometimes rely on arbitrary estimates of the disaster risk and return period, when examination of the historic record could give a more accurate estimate. The proportion of potentially preventable losses that will be achieved by a given hydromet investment is often arbitrary.
- All studies are ex ante. Some form of ex post validation would increase the confidence that prospective benefits are attainable.

F3. Comparison of Analytic Models of Climate Change Impact on Hydropower

Study	Modeling approach and issues	Findings on climate impact	Adaptation recommendations
Nepal: Khimti 1 60 MW run of river Stenek Connell Firth Colley (2011)	4 GCMs*2 emissions scenarios. A regression model related past annual climate conditions to water flows. The regression was then used for future projections. However, water flows for 1985-1994 were drastically higher than for 1995-2006. Projections were made based on each of these differing baselines. No reliable info on snowpack contribution to summer runoff.	GCMs gave widely varying precipitation projections—some increasing, some decreasing. (Basin is highly dependent on monsoon rainfall, but monsoons are poorly modeled.) These changes were added to divergent baselines. Hence, uncertainty was too great to allow quantitative impact assessments.	Because the plant is already in place, recommendations are no-regret, low regret, and adaptive management, emphasizing ongoing monitoring of flows and enhancement of capacity. Model results not used to assess recommendations.
Kafue Gorge Lower 750 MW station, part of a 3 dam, 3 reservoir system with important environmental flow requirements Stenek and others 2011	3 GCMs * 2 emissions scenarios were statistically downscaled and fed into a hydrological model to assess financial and flood risk impacts. Only one realization of each GCM was used, leading to incorrect interpretation of climate impact. (see note*).	Baseline IRR=21.6% IRR under climate change=19.7±2.4% Average annual loss from drought increases from current \$2.1 million to \$3.4 to \$5 million over 2010-2039. Flood and landslide losses are small.	A variety of no regrets and low regrets measures were proposed, together with costlier ones (increase reservoir capacity). But there is insufficient information to assess costs and benefits.
Zambezi Basin Basinwide modeling of hydropower and irrigation Strzepek and others 2011	56 GCM/emission scenarios applied to basin models without downscaling.	Almost all GCMS show a reduction in precipitation; mean reduction is 20%. This is projected to heighten the tradeoff between power production and irrigation, because water availability is reduced. Power production has a higher economic value, but irrigation provides much more employment.	Repeat analysis with a more refined model, reassessing investment plans and considering agricultural adaptation options.

**Note:* The Kafue Gorge Lower analysis compares projected outcomes for 2010-2039 under the A2 (high) and B1 (low) global emissions scenarios, finding divergent results. It concludes that the economic returns will be lower under A2. However, a well-known feature of these scenarios is that the higher emissions under A2 do not noticeably affect the overall atmospheric accumulation of CO₂—and hence have little impact on the climate system—until the 2040s. So it is implausible that KGL performance would drastically differ between the two scenarios. The difference appears to reflect random variation between a single realization of each scenario. That is, many possible weather sequences are compatible with each of the two emissions scenarios. By chance, the study arrived at a particularly unfavorable A2 scenario and a favorable B1 scenario. A side analysis ran 9 randomly “tweaked” versions of A2, arriving at a range of possible outcomes (reported in the findings column above).

Appendix G

Evaluation Methodologies

G1. Selection of SLWM and Watershed Project Sample

There is no formal categorization of sustainable land and water management or watershed management projects. A portfolio was compiled by amalgamating the following sets of projects:

1. Land management projects (approved FY01-11) identified by the Agriculture and Rural Development Anchor. These comprise the types listed below. There were 95 active and 35 closed projects. Of the 35 closed projects, 14 were identified as being related to sustainable land and water management.

- Land Conservation Research
- Erosion Control
- Land Protection
- Integration of Strategy for Sustainable Land Management
- Land management research and extension
- Land degradation prevention and control
- Sustainable land management practices (such as no-till farming, agroforestry, mixed cropping, etc)
- Impact measurement
- Land Resources Management (e.g., terracing, crop/pasture rotation, conservation tillage, buffer strips, pastoral /rangeland/ forest land management, watershed management)
- Land Resources Conservation (e.g., combating desertification, soil degradation, soil erosion, pollution control, land related biodiversity)
- Land resources management research and extension

2. Watershed management projects, as identified by an ENV review that covered projects approved 1998-2010. This was augmented by a search for “watershed management” within the objectives and components of closed agricultural projects reviewed in IEG’s Agriculture Evaluation for the same period. There were 49 active and 23 closed projects. Of the latter 12 were identified as being mostly devoted to watershed management; 4 were also listed in the land management portfolio mentioned above.

G2 Construction of Disaster Risk Management Portfolios

The 2008-10 portfolio reviewed by IEG was extracted from a 2006-10 disaster portfolio identified by GFDRR. The GFDRR portfolio was identified as follows.

First, identify all Bank projects that meet one of the following criteria:

- a) Are in the Natural Disaster Management, Flood Protection, and General Water Sanitation and Flood Protection sector and theme codes
- b) Are not in these sectors but include any of the following keywords: natural disaster, hazard, earthquake, hurricane, drought, cyclone, landslide, mudslide, tsunami, storm, volcano, flood, tornado, typhoon, blizzard, heat wave and cold wave.

Then, among the identified projects, select projects that meet one of the following criteria:

- a) Use of the Emergency Reconstruction Loan instrument
- b) Inclusion of at least one full disaster component or an identified disaster activity below the component level.

Starting with this set of projects, the IEG review included only investment projects (it excluded development policy operations, recipient executed activities and projects IEG deemed to have no significant disaster activity) for climate-related disasters (it excluded volcano and earthquake projects) for 2008-10.

Of the 90 projects, 36 were identified by GFDRR as related to floods, 15 to storms, 5 to drought, and 34 to multiple disasters, other disasters, general disaster risk management, or climate change adaptation. Many of the projects identified as climate change adaptation were related to agriculture or drought.

The 1984-2007 portfolio was created as described in IEG 2006; it included all projects with any activity related to disasters, but excluded activities that could have plausibly reduced disaster risk if they were not specifically mentioned as contributing to disaster prevention. The 1984-2007 portfolio categorization is identified by assigning activities identified in that portfolio into the 2008-10 categories, rather than manually re-examining the entire portfolio. As a consequence, the comparison is illustrative but not exact.

Appendix H

Additional Evidence

H1. Locations of Agriculture Projects in Africa

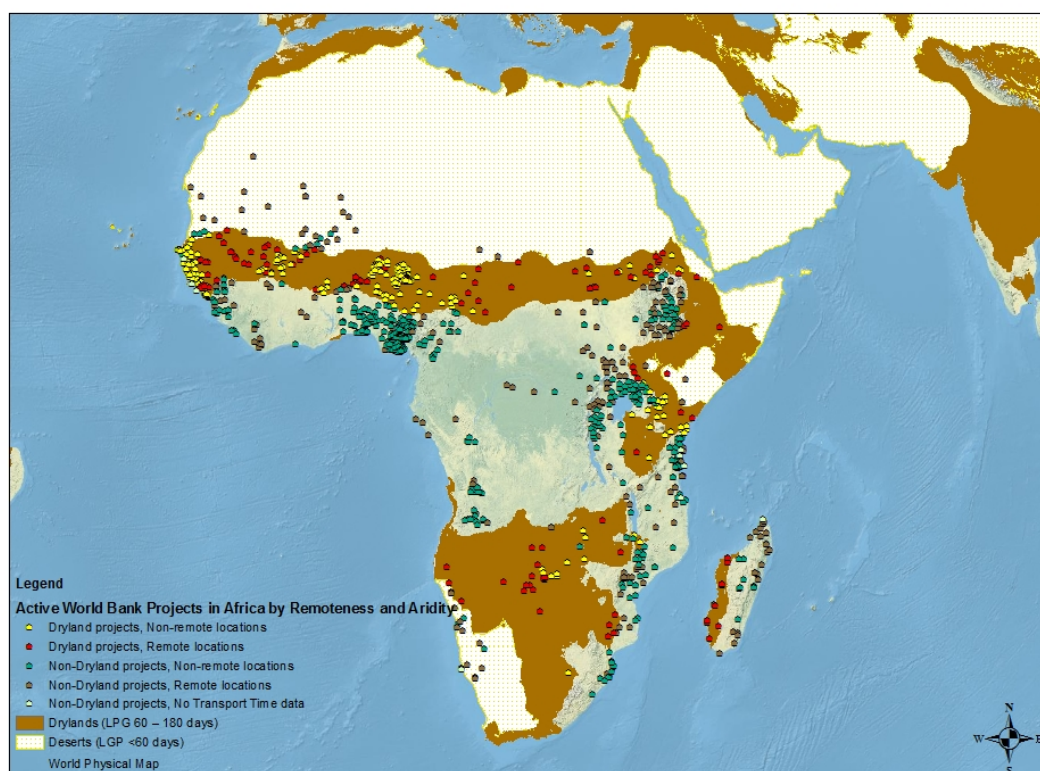
Table H.1 and Figure H.1 show the geographical distribution of active project locations by aridity and remoteness.

Table H.1. Distribution of African Agricultural Project Locations by Remoteness and Climate Zone				
Land type	No travel time data	Non-remote	Remote	Total number of locations
Subhumid & humid	15	482	190	687
Desert		18	47	65
Drylands		257	124	381
Total	15	757	361	1133
<i>Note:</i> Data are from 84 active projects with location information at the subnational level.				
<i>Source:</i> IEG calculations				

Focusing specifically on the drylands, Table H.2 looks at the proportion of projects concerned with SLWM. Attention focuses on the projects in the remote drylands, since these are likely the poorest and most vulnerable locations. Although the majority of these projects by count involved biodiversity conservation, those with SLWM accounted for three-quarters of the expenditure. The projects typically followed a community-driven development model, where communities chose from a menu of options. In most cases, capacity development was also supported. This is true also for the projects with mixed remote/non-remote locations.

Table H.2. African Dryland Projects by Remoteness and Inclusion of SLWM					
	Locations	Number of projects	Number of projects with SLWM	Commitment amount (\$millions)	Share of commitments in projects with SLWM
	Remote	15	5	250.5	74%
	Non-remote	20	7	354.4	57%
	Mixed	23	9	489.4	56%
<i>Source:</i> IEG calculations					

Figure H.1. Map of Active World Bank Projects in Africa by Remoteness and Aridity



Note: some projects have multiple locations. Only projects with location data at the subnational level are included.

Source: IEG, based on LADA drylands and WBI geolocation of projects. Jan 12 2012

In sum, a substantial proportion of World Bank agriculture investments in Sub-Saharan Africa target SLWM activities at climate-sensitive locations. The next section assesses lessons from analogous, completed projects.

The main data sources for the mapping exercise were the following:

- Location data of the active World Bank portfolio, as of September 2011, provided by the World Bank Institute Mapping for results Team. Projects were mapped if their precision code was 4.2 or less. Some of the non-mapped projects are inherently not mappable, for instance policy loans or other national-level efforts.
- Climatic zones (based on Length of Growing Period), poverty characteristics and population data of the FAO LADA project (Nachtergaeel and Petri 2011).

Drylands are defined (FAO/IIASA 2010) as having a growing period length of 60 to 180 days.

- Accessibility map, created by Siobhan Murray. Areas were classified as remote if they were more than 5 hours travel time from the nearest city of 100,000 or more

H2: Economic Value of Mangrove Coastal Protection Benefits

IEG examined 16 completed World Bank projects approved since 1990 of which 8 identified coastal protection as a project impact (even if coastal protection was not necessarily an objective or goal of the project). But these projects provided little evidence on the economic value of coastal protection benefits.

In the cases where disaster risk reduction benefits were estimated, they were for project-wide benefits (which came primarily from dikes or other forest benefits) without a breakout for the mangrove component. In one case, the percentage of disaster damage that would need to be averted in order for project benefits to exceed costs was estimated at 4.62 percent, but the likelihood that this target would be surpassed was merely asserted as “likely” without any further analysis. In another case, the main economic analysis did not include “unquantifiable” protective benefits from mangroves, but a secondary calculation assumed mangrove values of \$3,100-\$3,800 per hectare (based on extrapolation from estimations used for other, unnamed regions). Where economic returns from afforestation benefits are measured, these are usually due to economic benefits from aquaculture rather than estimating the value of protective benefits. In some cases, attribution of project impacts on forest cover is also unclear, because the project overlapped with other (sometimes much larger) programs outside of the project aimed at supporting mangrove afforestation in the same region.

A number of papers attempt to estimate the “total economic value” of mangrove and other wetland ecosystems, which includes direct benefits, option values, and existence values. But most of these focus primarily on forest goods and services (such as timber and fisheries), and many that estimate protective benefits use questionable methodologies. For example, Gunawardena and Rowan (2005) use a replacement cost approach (“what would be the cost of building a physical coastal protection system in this area, if mangroves were removed”) but fail to consider whether it would be optimal to build such a system and without considering whether mangroves provide equivalent protective benefits to the proposed physical barriers. This method can thus dramatically overstate the protective benefits provided by mangroves. Other papers (Ramsar Convention on Wetlands 2005) risk misstating the benefits of coastal protection by calculating an average benefit per

kilometer of forest based on those areas that were protected, while ignoring the fact that the average benefit of avoided losses depends on the value of assets protected, which will not remain constant outside of the sample zone where mangroves were planted. Barbier (2007) uses an expected damage function approach that estimates the value of coastal protection benefits based on coastal disaster data and mangrove coverage from Thailand, and find much lower values than are generated from a replacement cost approach. But weaknesses in the available data on disaster damage, mangrove coverage, and other factors that drive disaster losses suggest that their point estimate (loss of one square kilometer of mangrove leads to an increase of expected storm damages of \$585,000) should be interpreted with caution.

Efforts to estimate the coastal protection benefits of mangroves are complicated by a high degree of spatial variation in impact, depending on topography, vegetation properties, and the types of storms involved. For example, Kabir and others (2006) model the effect mangroves in reducing storm surge from a 1970 cyclone on Hatia Island in Bangladesh. They find that while in some locations mangrove afforestation with a width of 133-600 meters leads to reduction in storm surge height of 0.18-0.45 meters, in other locations the protective benefits were negligible. Mazda and others (1997) study mangrove zone on the Tong King delta in Vietnam, and find no significant reduction in storm surge in areas with immature mangrove cover, but wave height reduction of 20 percent per 100 meters of mangrove in areas with sufficiently tall trees. Badola and Hussain (2005) measure economic losses in three villages in Orissa hit by a 1999 cyclone, and find the greatest loss per household was suffered in a village with an embankment but no mangroves (\$153.74), followed by a village with no embankment and no mangroves (\$44.02) with the least damage occurring in a village with mangroves (\$33.31). The fact that a given storm has such drastically different effects on different villages (even those close to each other) makes it difficult to estimate the marginal value of mangrove cover because of the economic and geographic heterogeneity at the village level. Das and Vincent (2009) evaluated the protective effect of mangroves for the same cyclone over a wider area, using geographical data on geophysical and socioeconomic factors. They found that mangroves had a statistically significant protective effect and on average, for this event, one hectare of mangroves averted 0.0148 deaths.

Appendix I

Project Examples

Appendix I1: Water Efficiency in China

The Irrigated Agriculture Intensification Loan III (IAIL 3) approved in 2005 was designed to increase agricultural productivity and water efficiency in the Huang-Huai-Hai river basin in northern China. The project financed water-saving irrigation and drainage, agricultural institutional development and agro-ecological protection, and aimed to demonstrate these techniques as a model to be scaled up by Chinese agricultural agencies.

The project had not specifically considered climate change during preparation, but shortly after implementation the Bank successfully encouraged the addition of a climate change add-on. A set of climate change impact analysis studies were undertaken by international and domestic climate experts during preparation of the add-on, and the GEF-financed project on Mainstreaming Climate Change Adaptation in Irrigated Agriculture was approved in 2008. A consultative gap analysis undertaken as part of preparation of the adaptation project led to a new focus on demand-side water efficiency measures.

The project supported hydrological modeling of the basin under future climate scenarios. The studies improved understanding of the hydrological functioning of the basin and its response to different possible future conditions. Liu and others (2010), for instance, found that, in the absence of CO₂ fertilization, both irrigated and rainfed maize and wheat yields would decline modestly for a +2°C increase and severely for a +5° increase, with some moderation or exacerbation depending on precipitation trends. The climate change studies recommended a set of actions that were largely no-regrets measures that reduced vulnerability to current climate variability. The Bank claimed that the incorporation of demand-side water efficiency measures was motivated by the climate change technical studies—but the China Water Conservation project approved in 2000 had already undertaken similar measures.

Activities supported by the projects appear to have been highly successful; IAIL III reported a 27 percent increase in grain yields, a 75 percent increase in cash crop yields, and a 55 percent decrease in water use. The projects appear to have been successful in building institutional capacity in China, and in creating mobile expert teams that supported collaboration between national scientists, local experts, and extension agents. Water savings from improved infrastructure under IAIL 3 were

complemented by agronomic water savings from improved management and reduced evaporation due to methods piloted under the Mainstreaming project. The projects supported innovative measures for monitoring evapotranspiration through a combination of remote sensing and ground-based data collection. Demonstration mechanisms were directly incorporated into the projects, with experts from additional regions included in training and in creation of an online platform for result dissemination.

Appendix I2: Design and Maintenance Failures Associated with Emergency Projects

The rushed nature of emergency response projects makes them particularly vulnerable to design and institutional problems.

In an emergency flood project in Cambodia that closed in 2005, the project was successful in repairing flood control schemes, roads, and other infrastructure, but the repaired infrastructure was not sufficiently maintained. After only three years, many embankments were failing due to flood damage and were in need of repair, but no funds were available(IEG 2007a). An IEG evaluation noted that the institutional reforms needed to provide for maintenance were beyond the capacity of the emergency project to provide, and that a sustainable outcome would have required relationships and resources beyond those that are typically available in an emergency project (IEG 2007). An IEG evaluation of the Fourth Social Investment Fund Project in Honduras(IEG 2006c) noted that schools and a health center were reconstructed in a high flood risk zone and were likely to be destroyed again, and that drainpipes constructed by the project were of insufficient capacity and so houses and harvests were destroyed again by floods in the next rainy season.

In an emergency flood and earthquake recovery project in Turkey, a rushed disaster needs assessment meant that a significant amount of excess infrastructure was constructed, without considering likely beneficiary demand. Twice as many housing units were built as were needed, and the excess were wasted (IEG 2005). The rushed design process also overestimated the speed at which disbursements could be made, leading to many construction projects to start early and then stall when funds were not available.

An emergency recovery and disaster management program in St. Lucia was successful in building urban drainage systems and retaining walls along rivers, nontraditional efforts were largely unsuccessful. An attempt to reintroduce river meanders (and so to slow river flows) were not constructed correctly, pilot efforts at watershed management were not completed, bankside trees and grasses were not

planted and rural ditch systems were not completed. In all, 18 percent of the cost of flood works was lost when infrastructure proved to have insufficient disaster resistance. An IEG evaluation noted that “pressure to start reconstruction too soon after disaster led to inadequately analyzed designs and works implemented in a way that did not systematically reduce vulnerability to the next storm” (IEG 2005).

A water sector institutional strengthening project in Trinidad and Tobago was largely unsuccessful in both construction of flood control and drainage works and in its institutional reform because a hasty project preparation process that tried to combine rapid emergency assistance with long-term aid to the water sector resulted in insufficiently broad consultation and failed to appreciate the extent of political risks (IEG 2003).

Appendix I3: Completed Mangrove Projects with Coastal Protection Benefits

The Forest Resources Management project in Bangladesh (approved 1992, closed 2001) was originally intended to plant 32,900 hectares of mangroves to help consolidate newly accreted land in the Bay of Bengal, and was expected to provide protection against cyclonic storm surges. The mangrove target was revised downwards in 1996 to 26,000 hectares because of a reduction of siltation meant that less land was available to be planted. The revision was reversed after the 1998 floods brought a large accretion of sediment. Actual planted areas covered 32,900 hectares at an average coverage of 7,000 seedlings per hectare, with good initial survival rates. The project economic analysis claims that the mangrove component achieved a 12 percent ERR (compared to 24 percent at appraisal) and that this includes some protective benefits from mangrove planting, but details on how protective benefits were estimated were not available. The large reduction in ERR was due largely to lower-than-expected timber yields, due to growth rates being much slower than expected and to disease; planned rotation was changed from 17 years to 40 years.

The Coastal Embankment Rehabilitation project in Bangladesh (approved 1995, closed 1999) supported afforestation of embankment slopes and foreshore with mangroves and other vegetation as part of a disaster risk reduction program. The program had a target of 1900 hectares of afforestation on embankment slopes and 4,900 hectares on foreshore slopes. These were revised downwards to 850 and 2350 hectares, respectively. Actual achievements were only about 663 and 822 hectares, in part due to poor incentives. Local government owned the foreshore land intended to be planted, but could achieve higher financial returns by leasing the land out for shrimp or salt production rather than undertaking mangrove afforestation. Local government specified that 20 percent of leased land be used for afforestation, but many lessees did not agree or did not follow through, and government had little

ability to monitor or enforce afforestation. Considerable areas of foreshore planting were removed by fishermen and replaced by commercial fishing activities, and the areas where mangroves remain were often those where population and fishing pressure was relatively low (and so protective benefits may have also been low). Economic benefits were not separately estimated for afforestation and embankment work. Maintenance of the embankments was often poor, but embankments were in better shape in areas where afforestation had occurred.

The Andhra Pradesh Hazard Mitigation and Emergency Cyclone Recovery Project in India (approved 1997, closed 2003) supported shelter-belt plantations in coastal areas to provide protection from cyclonic storms and floods. Plantation targets were achieved, with 606 hectares of mangrove plantation achieved along with 3,581 hectares of casuarinas and 1,089 hectares of palmyra. Survival rates of planted mangrove seedlings were low – varying across plantations from 20 percent to 50 percent – which was attributed to use of poor-quality seeds.

The Coastal Wetlands Protection and Development Project in Vietnam (approved 1999, closed 2007) was designed to reestablish coastal mangrove wetlands in order to promote aquaculture and provide coastal protection. The mangrove planting component was initially expected to cost \$13.9 million and to cover 26,400 hectares, but dramatic increases in land values in coastal areas meant that the opportunity cost of planting land with mangroves would have been higher than expected in many areas, and so the mangrove target was revised downwards to cover only 3,898 hectares. Mangrove plantations covering 5,876 hectares were achieved, focusing on barren areas in protected zones, at a cost of \$3.8 million. Forest coverage in the project zones increased from 48 percent to 96 percent, and coastal erosion decreased (by 40 percent in one province) due to mangrove plantations, but the protective impact could not be attributed solely to the Bank project, since up to 80 percent of afforestation in the project provinces was accomplished by the separate government of Vietnam Program 661. Survival rates of plantations were very variable, due to the incidence of storms in newly planted areas, and the fact that many saplings were planted when still immature. In some zones, all mangroves were wiped out, despite multiple plantings.

The Andhra Pradesh Community Forestry Management Project in India (approved 2002, closed 2010) focused mainly on management 340,000 hectares of teak and other forests, but was redesigned after the 2004 tsunami to also allocate \$5.5 million for the establishment of 2,310 hectares of shelter belts and rehabilitation of 2,190 hectares of mangroves in river deltas. Little information is available about the mangrove component, but the ICR (World Bank 2010d) reports that survival rates were high

and that mangrove reforestation was successful due to both planted seedlings and natural regeneration.

Appendix I4: Financing the Caribbean Catastrophe Risk Insurance Facility

The Caribbean Catastrophic Risk Insurance Facility is an example of a successful multicountry insurance risk pool. The facility is designed to reduce the impact of natural disasters by providing member countries with insurance payouts sufficient to cover short-term liquidity needs in the aftermath of an earthquake or hurricane. Its 16 members pay risk-based insurance premiums (calculated from risk modeling work supported by technical assistance from the World Bank Treasury) to purchase a desired level of insurance coverage. The instrument is designed to cover only short-term needs, estimated to comprise at most 20 percent of losses.

The World Bank, through IDA, funded the participation fees, 100 percent of the first two years' premiums, and 50 percent of the third year's premium for Haiti, Dominica, Grenada, St. Lucia, and St. Vincent and the Grenadines. It also funded 50 percent of the fourth year's premium for Dominica and St. Lucia.

The facility has been successful in offering insurance at a lower rate than would be available had each country tried to purchase insurance separately, or if each country had to maintain its own reserves separately. A World Bank document estimated that the premium was 68 percent lower than the cost of meeting similar risks through domestic reserve funds (Ghesquiere and Mahul 2007). In addition, some very small countries may have been effectively uninsurable on an individual basis. Cost savings come from economies of scope and scale; it was cheaper to undertake risk modeling for the Caribbean in a coordinated fashion, it was more efficient to undertake a single client education program, and the transaction costs of operating the facility are lower than would exist for a set of separate insurance contracts (due in part to the small size of member countries).

Payouts as of 2011 have totaled \$32 million across 8 claims, with all payouts being made within 3 weeks of the event. The following CCRIF members have received payouts: Dominica and St. Lucia after a November 2007 earthquake; Turks and Caicos after Hurricane Ike in September 2008; Haiti after the January 12, 2010, earthquake; Anguilla after Hurricane Earl in September 2010; and Barbados, St. Lucia, and St. Vincent and the Grenadines following Hurricane Tomas in October 2010. In the financial year 2009-10 (the most recent for which full accounts are available) gross income from premiums was \$21.5 million, as compared to payouts of \$7.8 million, and equity in the facility was \$67.5 million, so the facility appears to be operating sustainably (CCRIF 2010).

The CCRIF manages risk with a layered risk structure. For 2009-10 aggregate the facility had a maximum potential liability of roughly \$600 million; the facility itself retains risk for claims up to \$20 million (paid out of reserves), and then transfers higher levels of risk to insurance and reinsurance markets, using the IBRD as an intermediary. The facility reinsures most of its risk externally, and is financially self-sustaining. The use of simulated rather than actual losses allows for rapid response and lower cost than under traditional indemnity insurance. However, damage models that relied on wind speed rather than rainfall meant that significant basis risk remained; the CCRIF made no payout following Hurricane Dean in 2007, as the main damage came from flooding rather than wind damage. CCRIF intends to offer excess rainfall coverage in future.

Based on IEG interviews and a CCRIF beneficiary assessment, member governments seem generally happy with the CCRIF. They find that the insurance is reasonably priced, with good service and rapid payouts, and many countries would be interested in seeing the CCRIF expanded to offer insurance cover for other hazards.

While the CCRIF has been a successful instrument for managing disaster risk in the Caribbean, the opportunities for replication of the multi-country risk pool model remain unclear. The CCRIF opportunity arose in part because of case-specific factors; a set of disaster-prone countries with a similar but low correlation risk profiles, the small size of these countries (which meant that transaction costs from traditional insurance would be significant), and the shared trust and prior experience between member countries in working together on disaster risk management. Discussions are in progress for a disaster risk pool for Pacific Island nations and a drought risk facility for Africa.

Appendix I5: Index-Based Insurance in India and Mongolia

Though most index insurance pilots have not led to scaling up, two Bank-supported index insurance projects are operating at large scale.

The Weather Based Crop Insurance Scheme in India is by far the largest in the world; as of 2010-11, over 9 million farmers were enrolled, with annual revenues of \$258 million, insuring \$3.17 billion of assets (Clarke, Mahul, and others 2012). The scheme draws its origins from a 2003 pilot in Andhra Pradesh, which received World Bank technical assistance. The WBCIS system relies heavily on public subsidies, with premium rates capped at 1.5-2 percent of insured value for wheat and other food crops, and over 2007-10 total payouts exceeded total premiums by 30 percent. Participation by farmers is largely compulsory (it is tied to credit access), though some farmers participate voluntarily. So widespread adoption is

APPENDIX I

PROJECT EXAMPLES

unsurprising. Basis risk remains significant; farmers who suffer a total crop loss will still have a 1 in 3 chance of receiving no payment from the WBCIS (Clarke, Mahul, and others 2012).

The ongoing Index-Based Livestock Insurance Project in Mongolia has been the most successful livestock index insurance to date. Implemented in 2006, the product insures losses of livestock caused by severe winter weather, and provides payouts to herders based on the average losses of livestock in each district. The instrument contains both a base layer (for losses up to 30 percent) that is intended to be commercially viable, and a catastrophic layer (for losses exceeding 30 percent) that is subsidized by government. The product has performed relatively well in attracting customers; in 2010/11, 10.5 percent of herders in the target areas purchased insurance (covering on average 30 percent of the value of the herds of those who purchased insurance), and premiums collected were roughly \$330,000 across 7,000 policies (Luxbacher and Goodland 2011). However, observed uptake may have been due in part been to three successive years of severe winters and high payouts (including the worst winter ever recorded in 2009/10), which have strained program finances. Cumulative premiums up to 2010/11 have been \$750,000 for the basic layer while cumulative payouts for this layer have been \$1.9 million. The long-term financial sustainability of the program thus remains in question.

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Endnotes

¹ Lobell, Schlenker and Costa-Roberts (2011) find that in 65% of countries, the mean 1980-2008 increase in growing season temperature for maize in rice is equivalent to at least one standard deviation of year-to-year variability; for a quarter of countries, the increase is at least two standard deviations.

² Protection against current hurricane risks is here considered as providing a net benefit 'today' even if no hurricane materializes.

³ This is an infelicitous term, since it incorrectly implies that other actions are regrettable. It is often used to mean actions that are justified whether or not climate change is occurring. But since climate change is, in fact, occurring, it is used here to refer to an action that will provide benefits under a wide range of possible climate change outcomes.

⁴ Figure 1 was constructed based on a count of the occurrence of 'adaptation' within 25 words of 'climate' in project documents; results were filtered to remove duplicate references to a project.

⁵ The 2012 Environment Strategy also has a results framework for its Resilience pillar, with indicators that overlap with those proposed in the SFDCC close-out report. The Environment Strategy framework includes an indicator: "Percentage of projects (mapped to Environment) with gender analysis, gender-inclusive consultation, or both."

⁶ IDA 2011. "Additions to IDA Resources: Sixteenth Replenishment IDA16: Delivering Development Results" Approved by the Executive Directors of IDA on February 15, 2011 (and modified on March 18, 2011)

⁷ Quotes are from <http://climatechange.worldbank.org/content/tracking-finance>. The typology is published at <http://climatechange.worldbank.org/sites/default/files/Typology.pdf>. (Both accessed 18 July 2012.)

⁸ Some examples are drawn from a review of the FY12 pilot application of the tracking system.

⁹ Climate sensitive sectors here include transport, agriculture, water, and urban development.

¹⁰ IFC Management notes that some aspects of the risk analyses were considered proprietary and were not reflected in the published material.

¹¹ Based on active projects, May 2012. Excludes short-term loans of 2 years or less.

¹² A significant focus on climate adaptation actions was defined as including climate adaptation as a pillar, or being included in a sub-pillar objective with multiple climate-resilient activities in the results matrix. Strategies where actions were suggested as future

possibilities, where climate adaptation was limited to vague mainstreaming in existing sectors, or where only one formal activity was supported were classified as modest. Many of the former strategies included a pillar on climate change, though often merged with environmental sustainability, natural disasters, or agriculture. Some of the latter strategies outlined interesting possibilities for future action that had not yet been formalized in the program as of the CAS (such as in Cameroon, Poland, and Armenia).

¹³ Ongoing analytic work in Bhutan, not mentioned in the CAS, relevantly focuses on the climate sensitivity of the expanding hydropower sector, which already accounts for 19% of the country's GDP and 39% of exports.

¹⁴ Of countries for which a CAS was produced that did not consider explicitly consider climate resilience, the 10 most vulnerable countries according to the Global Adaptation Institute Index were the Central African Republic, Lesotho, Congo, Burkina Faso, Burundi, Liberia, Cote d'Ivoire, Rwanda, Djibouti and Benin. Half of these are fragile states according to the 2012 definition. Note that the Global Adaptation Institute Index includes a high weight on lack of capacity.

¹⁵ The UNFCCC established LDCF in 2002 to assist the least developed countries with adaptation. It supported the developed of NAPAs (national adaptation programs of action) and of projects. The UNFCCC established the SCCF (which also supported technology transfer) in 2004. Both of these funds are administered by the GEF. In addition, was also asked to pilot adaptation measures via the SPA, which was funded from the GEF trust fund and supported projects that had global environmental benefits. Most of the projects from these funds (with the exception of the NAPAs) are ongoing. Preliminary evaluations of these program include GEF Evaluation Office. 2010. Evaluation of the GEF Strategic Priority for Adaptation (SPA) , GEF Evaluation Office. 2011. Evaluation of the Special Climate Change Fund (SCCF). Washington, D.C., GEFEO.

¹⁶ This section draws on IEG(2012) PPAR of Caribbean Adaptation Projects.

¹⁷ The overall grant was in US dollars, whose value declined over the course of the project.

¹⁸ This section based on an IEG mission to Colombia, October 2011.

¹⁹ The project had initially intended to work in a different watershed, where water flows from the paramo fed into a hydropower plant supported by the Bank's carbon finance program. The location was changed for security reasons.

²⁰ These innovations were introduced in the Water Conservation Project (2000-6), and expanded in the \$200 million Irrigated Agriculture Intensification Loan III (IAIL III, 2005-11), both in the 3-H Basin, a breadbasket of China. An add-on GEF project (2008-) looks explicitly at climate adaptation needs and response. The ET approach has been further refined in the \$100 million Xinjiang Turfan Water Conservation Project (2009, ongoing), situated in an arid region.

²¹ This paragraph based on World Bank (2007), *World Development Report 2008: Agriculture for Development*.

²² In Ethiopia, communities were offered a choice of development projects, and more than half chose some form of SLWM. In Zambia, 35% of project participants adopted conservation farming, boosting yields by 25% (Program Against Malnutrition 2005).

²³ The impact evaluation compared outcomes of households receiving five years of support with comparable households receiving one year of support. A household was considered food-insecure if it could not satisfy its food needs for five or more days in a month.

²⁴ Precursor projects dated to the mid-1980s and included the Emergency Drought Recovery project of 1993.

²⁵ In 2007, 0.9% of the value of global agricultural output was covered by insurance; 2.3% in high income countries, 0.3% for upper middle income countries, 0.2% for lower middle income countries and 0.0% for low income countries. (Mahul and Stutley 2010)

²⁶ Climate disasters are defined here as droughts, floods, storms, heat waves, cold waves and landslides.

²⁷ The 2006 evaluation found that at the project level, objectives had mainly focused on short-term fixes and had rarely addressed the root causes of the disastrous impacts of natural hazards. The short term focus had been driven in part because disaster prevention measures had been tied to disaster response projects, and because disaster response projects were often implemented through the Emergency Recovery Loan (ERL) instrument, which had a short planning period and a maximum 3 year implementation period.

²⁸ This period follows the adoption of the Hyogo Framework in 2005, the IEG evaluation of 2006 and the creation of GFDRR in 2006. It is possible that a general shift in international awareness of the importance of risk reduction measures--reinforced by the South Asia tsunami of 2004, one of the worst disaster events in history--has been the driving force behind these events and the observed change in behavior in the Bank. This evaluation could not determine attribution for this change.

²⁹ These projects were identified by a keyword search of project appraisal documents for "mangrove," followed by a manual examination. A further 9 projects remain active. In all cases the mangrove planting was a small part of a larger project, often with conservation, forest management, disaster response, or disaster risk management objectives

³⁰ Dasgupta and Blankespoor World Bank. 2010b. Economics of Adaptation to Climate Change – Ecosystem Services. Washington, DC, The World Bank. use GIS data to examine the degree to which mangroves are threatened by sea level rise. They find that 69% of mangrove coastline in developing countries would have the ability to migrate inland from a 1 meter sea-level rise, 22% would be threatened but might be able to migrate, and 9% would be blocked from migration by topography – but that this 9% covers 28% of the population in mangrove-protected areas and 41% of the GDP."

³¹ The Ministries of Finance and Agriculture have expressed interest in the index insurance product; they may purchase the index insurance product as a means of providing funds that can then be used to pay for reconstruction of government assets or social protection measures for farmers, respectively, in the event of flood, earthquake or drought.

³² Flood insurance penetration in the USA is only 50% even in flood-prone areas (Dixon et al 2006). In Germany one third of households have no flood insurance, and flood insurance covers only 10% of the value of residential buildings (Thieken, Petrow and others 2006). The vast majority of insurance coverage is in developed countries. For the global nonlife insurance industry in 2006, 82% of premiums were collected in Europe and North America, 13% in East Asia, 3% in Latin America and Caribbean, 1% in South Asia and 1% in Africa (The World Bank 2010).

Flood insurance in developed countries has existed for many decades, but often suffers from inadequate coverage, even when theoretically compulsory, may require expensive public subsidies, or may give insufficient incentive to reduce exposure or risks (Michel-Kerjan and Kunreuter 2011). For example, for 1 million households in Florida with compulsory flood insurance in 2000, one third of policies were cancelled by 2002 and nearly two-thirds by 2005 (Michel-Kerjan and Kousky 2010).

³³ Budget contingencies usually cover only 2-5% of government expenditures, and developing country governments often lack reserve funds that could be used to pay for disaster response (Ghesquiere and Mahul 2010), as these would have high opportunity costs and it can be difficult to preserve reserve funds given political pressures for spending.

³⁴ A previous IEG evaluation found that over 1984-2005 roughly \$3 billion was reallocated from 217 projects, and this reallocation could seriously disrupt project programs (IEG 2006) and could take months to be approved and years to disburse. For this climate adaptation evaluation, a survey of disaster projects over 2008-11 found no instances of inter-project reallocations being used in the wake of a climate disaster, as opposed to 12 reallocations over 1998-2001

³⁵ Cat DDOs have been signed for Costa Rica and Colombia (2008), Guatemala (2009), Peru and El Salvador (2010), and Panama and the Philippines (2011) with a combined credit line of over \$1 billion. Of these, Costa Rica, Colombia and Guatemala have triggered the option (for a total of \$259 million of borrowing).

³⁶ In some ways this calculation is conservative, but it is unable to incorporate the opportunity cost incurred by running up against a country borrowing limit constraint.

³⁷ The Bank introduced an Immediate Response Mechanism for IDA countries in 2011, whereby projects can be created with a disaster response component, and then funds can be rapidly reallocated from other components to the disaster component should a major disaster occur. The mechanism could help by providing rapid access to funds in the wake of a disaster, but may disrupt ongoing operations by diverting funds away from other components. No evidence is yet available on the effectiveness of this mechanism.

³⁸ Lane and Mahul (2008) examine data from 250 catastrophe bonds, and estimate the average price of catastrophe risk insurance at 2.69 times the expected loss. For low-frequency risks with return periods of 100 years, the market will often charge over four times the actuarial cost. Even for more frequent risks with 10 year return periods, the multiple is still close to twice the expected loss. These multiples are an average that cover both climate disaster (mostly cyclone) and earthquake risks, and within the sample cyclone cat bonds charge a multiple that is 10-50% higher than cat bonds for earthquakes.

³⁹ This review draws upon a GFDRR work product – “Strengthening Weather and Climate Information Decision-support Systems (WCIDS) The World Bank Portfolio 1996 to 2011” -- that is in preparation. The GFDRR WCIDS team kindly shared its early draft with IEG in support of our review.

⁴⁰ Information based on ICRs for Poland (P053796), Mexico (P007713), Peru(P054667), Dominican Republic

⁴¹ There has been increasing use of satellite-based remote-sensing measurements. World Bank studies have used TRMM (Tropical Rainfall Measuring Mission) data, which is freely available and covers areas that are sparsely gauged. However, remote sensing can never fully substitute for surface-based measurements.

⁴² “The transition to AWS is often instigated by a perception that these systems are cheaper to operate and easier to manage than human observers. The ETAWS cautioned that this was not the experience of a number of member countries. Therefore, it identified a number of responsibilities and costs that may not be immediately apparent to those that adopt automatic systems.” WMO. 2009. Implementation and use of Automatic Weather Stations (AWSs) (Submitted by the WMO Secretariat). AOPCXV Doc. 6.2a

⁴³ While some climate change studies attempt to describe the probability distribution of future outcomes, they typically do this by combining a large number of different climate models and/or parameter realizations and then implicitly assuming that each input possibility is equally likely. This generates a distribution across future climate states, but this is not a true probability distribution.

⁴⁴ See Ullsfjord et al, who find that a Norwegian hydropower plant should enlarge its capacity to take advantage of enhanced snowmelt over coming decades.

⁴⁵ A study of Asian Megacities (World Bank 2010) noted that “vulnerability mapping, land use planning and zoning could be used to restrict future development in hazardous locations, ultimately retiring key infrastructure and vulnerable buildings in these areas,” and support “zoning controls to ensure that low income housing is located outside of flood prone zones” for Ho Chi Minh City. It also identified “Retreat” as one of four possible adaptive options, noting “planning option[s] to reduce exposure can be applied in urban areas through urban land use plans and zoning codes.”

A study of North African coastal cities (World Bank 2010) calls for an integrated approach for detailed land use planning and urban design for Casablanca, factoring in climate-related vulnerabilities in considering use for vacant land. It notes that floodprone areas should be carefully screened to avoid worsening inundation and drainage problems. It notes that “climate-resilient urban planning will be crucial for Tunis to manage the risks caused by natural hazards and climate change,” recommending upgrading of drainage, containment of illegal housing and careful zoning with green spaces.

⁴⁶ An IEG search for projects supporting large scale spatial planning or land-use zoning for disaster risk reduction found only one example, the India Coastal Zone Management Project. Land use zoning projects were identified via text search of documents, polling of knowledgeable urban and land management staff, and review of a Bank-identified portfolio of active and pipeline land use planning and zoning projects over 2003-9 (World Bank 2009,

Background Note to the Interim Guidance on Land Use Planning Review of Environmental and Social Considerations in World Bank Land Use Planning Projects – Key Findings and Good Practice)

⁴⁷ Some agencies have adopted very high level guidance encouraging assessment of climate risk without providing context-specific advice.

⁴⁸ Agreed SLWM indicators are income, yield and biophysical indicators changes.

⁴⁹ Pre 2006 closure.

50 ISRO – India Space Research Organization Evaluations of Phase I and Phase II: ISRO. 2009. –Impact Assessment of Sujala Project: Final Report. □ Antrix Corporation, India Space Research Organization. Bengaluru. June 2009.

51 Baseline and control groups are established for the M&E for other than income, yield and biophysical indicators (except forest cover)

52 Economic analysis of a sample of 200 subprojects revealed considerable variability in the profitability of different types of activities. Consistently more profitable activities: poultry production, rice production, vegetable production, banana gardens, and grain milling. Consistently less profitable activities: production of basic cereals (sorghum, millet, beans, maize), small ruminant production, establishment of plant nurseries.

53 Three scenarios depending on financial sustainability: 1. Assuming no further funding for the incomplete sub-projects. 2. Assuming additional government resources for those that had already received two tranches. 3. Assuming additional government resources for those that had received either one or two tranches. The ERRs for these were 9 percent, 15 percent, and 19 percent respectively, all lower than the 21 percent projected at appraisal.

54 M&E by implementing agency has been adequate in the tracking of implementation progress, but weak in providing an assessment of the impact on agricultural production and farm incomes

55 PEMBH State (Bank-financed) Micro-catchment Program, Plantio Direto – minimum tillage

56 From ICR: The project did not fully succeed in setting up an effective Monitoring and Evaluation (M&E) system. This prevented the PMU from efficiently managing time, resources and project data and from taking appropriate and timely action.

57 Including non-accounted benefits.

58 (from 1.48t/ha (baseline) to 2.26t/ha)

59 from 1.55t/ha to 1.84t/ha

60 The area of settled rainy season rice grew from 37 ha to 47 ha, the area of settled dry season rice increased from 8 ha to 15 ha, and the number of village vegetable gardens increased from 103 to 185. But there is no indication in the ICR of the level of yield and output increases.

⁶¹ Resource Guide on Gender and Climate Change. UNDP, 2009. Training Manual on Gender and Climate Change. IUCN, UNDP and the Global Gender and Climate Alliance, 2009.

⁶² IEG reviewed agency documents and conducted interviews with staff in international development organizations and NGOs implementing activities on the ground in ASALs in an attempt to supplement, validate, and cross-check evidence from ILRI's impact analysis of ALRMP.

⁶³ Precursor projects dated to the mid-1980s and included the Emergency Drought Recovery project of 1993.

⁶⁴ DSGs and DMOs as well as key drought management products, such as drought monitoring bulletin and early warning system provide technical inputs into national drought management policy response efforts in the Kenya Food Security Steering Group (KFSSG), the Kenya Food Security Meeting (KFSM), and the Government of Kenya Coordination Structure for Crisis. The EU-funded Drought Management Initiative builds on the structures and ALRMP with a view to strengthen the role and capacities of DSGs. Key ALRMP drought management activities, such as the publication and dissemination of drought monitoring bulletin and early warning systems, have been incorporated into the Ministry for Development of Northern Kenya and Other Arid Lands (Min N&KAL). The experiences and lessons from ALRMP and DMI have informed institutional change for drought management and response through the creation of a National Drought Management Authority, (NDMA), and Drought Contingency Fund.

⁶⁵ Subsequent audit findings suggest, however, that recorded district expenditures may differ substantially from actual expenditures, so that the relationship may be stronger than the analysis detected.

⁶⁶ This analysis distinguished intervention vs. control locations based on a categorization by district staff. It found a .177 increase in z-score for the intervened locations, using a difference-in-difference approach. There was no significant difference when locations were characterized based on ALRMP expenditure – but as noted earlier, expenditure may be inaccurately measured.

⁶⁷ The impact evaluation compared outcomes of households receiving five years of support with comparable households receiving one year of support. A household was considered food-insecure if it could not satisfy its food needs for five or more days in a month.

⁶⁸ Other potential effects include increased damage to road surfaces through buckling from extreme heat, damage to road structures built in permafrost areas due to temperature changes, and accelerated rusting and degradation of some road infrastructure due to increased salinity, but these are likely of secondary magnitude

⁶⁹ For paved roads, changes in design standards may need to be made at increments of 10cm per year of annual precipitation or 3° Celsius increases in average temperatures, at construction cost increases of 0.8 percent for each increment (Lea International, L.D. 1995; NOAA 2009, FEMA 1998).

⁷⁰ This evaluation did not conduct a comprehensive portfolio analysis of road projects.

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