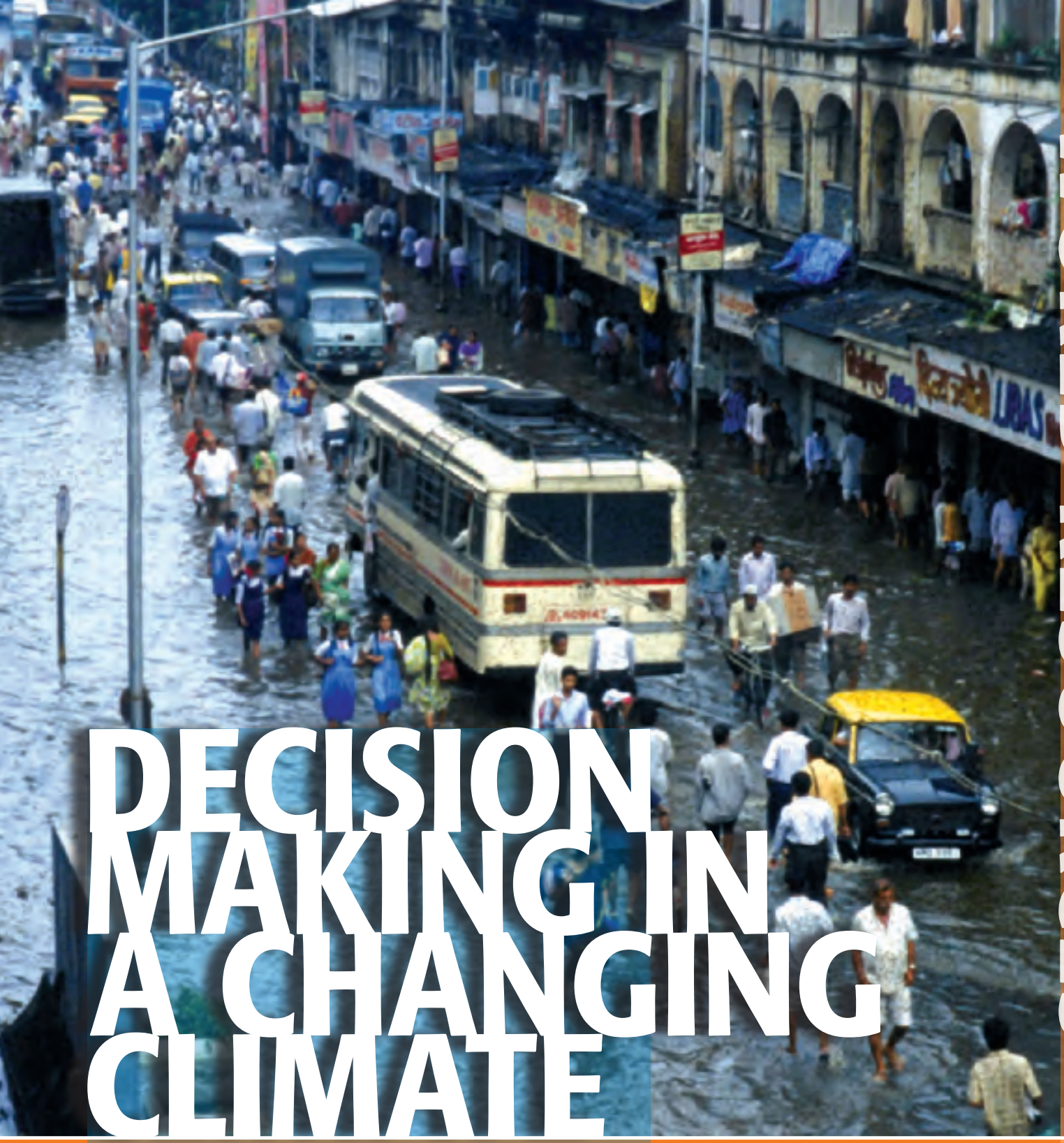

DECISION MAKING IN A CHANGING CLIMATE

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DECISION MAKING IN A CHANGING CLIMATE

DEDICATION

We are dedicating the *World Resources Report 2010–2011: Decision Making in a Changing Climate* to Bo Lim, the principal adviser on climate change, development, and adaptation at the United Nations Development Programme. She died this spring after an extended battle with cancer, a foe that she faced with the same spirit of resilience that she sought to inspire through her work on adaptation.

Bo cared so much about how climate change would affect the world's poorest, most vulnerable people and the countries they live in. She understood the unfairness of it and never let us forget that. But Bo also knew well that tackling the challenges of climate change and making progress to improve individual lives were the best antidote to frustration and the cornerstone of climate resilience.

Bo Lim was an enthusiastic and engaged champion of this report, so it is only fitting that we dedicate it to her memory and to her spirit.

DECISION MAKING IN A CHANGING CLIMATE

ADAPTATION CHALLENGES AND CHOICES

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CONTENTS

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GLOSSARY OF KEY TERMS

ADAPTATION: "Adjustment in natural or human systems to a new or changing environment. Adaptation to climate change refers to adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities." [1]

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" [2]

CLIMATE: "Climate in a narrow sense is usually defined as the 'average weather' or more rigorously as the statistical description in terms of the mean and variability of relevant quantities over a period of time ranging from months to thousands or millions of years. The classical period is 30 years, as defined by the World Meteorological Organization (WMO). These relevant quantities are most often surface variables such as temperature, precipitation, and wind. Climate in a wider sense is the state, including a statistical description, of the climate system." [3]

CLIMATE CHANGE: "Climate change refers to a statistically significant variation in either the mean state (see definition below) of the climate or in its variability, persisting for an extended period (typically decades or longer)." [4]

CLIMATE IMPACTS: "Consequences of climate change on natural and human systems." [5]

CLIMATE SYSTEM: "The climate system is the highly complex system consisting of five major components: the atmosphere, the hydrosphere (water), the cryosphere (ice), the land surface and the biosphere (living organisms), and the interactions between them." [6]

CLIMATE VARIABILITY: "Climate variability refers to variations in the mean state and other statistics (such as standard deviations, the occurrence of extremes, etc.) of the climate on all temporal and spatial scales beyond that of individual weather events. Variability may be due to natural internal processes within the climate system (internal variability), or to variations in natural or anthropogenic external forcing (external variability)." [7]

COORDINATION: The process by which different levels of government and different ministries, agencies and actors harmonize work on a common issue.

EXPOSURE: "The nature and degree to which a system is exposed to significant climate variations." [8]

EXTREME EVENT: "An extreme weather event is an event that is rare at a particular place and time of year. . . . By definition, the characteristics of what is called extreme weather may vary from place to place in an absolute sense. Single extreme events cannot be simply and directly attributed to anthropogenic climate change, as there is always a finite chance the event in question might have occurred naturally. When a pattern of extreme weather persists for some time, such as a season, it may be classed as an extreme climate event, especially if it yields an average or total that is itself extreme (e.g. drought or heavy rainfall over a season)." [9]

HAZARD: The physical manifestation of climate change/variability (e.g. precipitation increase) as it affects human systems. The outcome of a hazard is an impact. [10]

HEIGHTENED VARIABILITY: Increases in climate variability (see climate variability).

HUNDRED-YEAR EVENT: An event that has a 1 in 100 chance of occurring. [11]

LONG-TERM CHANGE: A change in the mean climate system that persists for decades or longer. [12]

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." [13]

MEAN STATE OF THE CLIMATE SYSTEM: Average state of the climate system over a given period.

MITIGATION: "An anthropogenic intervention to reduce the sources or enhance the sinks of greenhouse gases." [14]

NATURAL CYCLES: A process in which elements are continually cycled in various forms through different compartments of the environment (air, water, soil, organisms). [15]

RESILIENCE: "Amount of change a system can undergo without changing state." [17] Some view vulnerability as the opposite of resilience, meaning that a reduction in vulnerability is the same as an increase in resilience, [18] but resilience could indicate an ability to return to the status quo whereas reducing vulnerability can lead to an improvement from the status quo.

RISK: The probability of a hazard's occurrence. [16]

SENSITIVITY: "The degree to which a system is affected, either adversely or beneficially, by climate-related stimuli. The effect may be direct (e.g. a change in crop yield in response to a change in the mean, range or variability of temperature) or indirect (e.g. damages caused by an increase in the frequency of coastal flooding due to sea level rise)." [19]

VULNERABILITY: "The degree to which a system is susceptible to, and unable to cope with, 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." [20]

FOREWORD

CONDITIONS ARE CHANGING IN OUR WORLD. Some are feeling the impact now, from the heat wave and wildfires in Russia of the last two years, the devastating floods in Pakistan and Australia, tornadoes in the United States, mudslides in Brazil, drought in China. Others are worrying about the impacts to come: the tea growers in Kenya's highlands who are seeing cases of malaria they didn't see only five years ago; the cocoa farmers in Ghana who think about how changes in rainfall will affect their sensitive crops; the rice farmers in Vietnam who are increasingly concerned about rising water levels.

Around the world, there is a growing recognition that, no matter what steps may be taken to control greenhouse gas emissions, we need action to prepare for the likely impacts of greater climate variability and climate change. Governments increasingly realize that they need to make hard policy choices today about a world they may face in 20, 30, or 40 years from now—choices that take into account the scale, pace, and complexity of the risks presented by a changing climate.

This edition of *World Resources* is designed for governments making these difficult choices. The report is based on a broad research program and consultations with experts from more than 30 countries, and that research is publicly available on the WRR web site (*www.worldresources-report.org*). The report identifies five critical elements that will significantly strengthen the ability of national governments to make effective adaptation decisions:

- **Early and ongoing public engagement** on climate change issues, to ensure that people appreciate the risks, understand policy decisions, and have a voice in how they are implemented and monitored.
- **Information**, such as geographically relevant weather data, that is easily accessible, can be shared with those affected, and used effectively to make informed decisions for varying time-scales.
- **Institutional design** that allows governments to coordinate among agencies and stakeholders at local, sub-national, regional, and international levels, and to prioritize climate risks in planning and policymaking processes.
- **Resources**—financial, human, ecological, and social—at every level and over time.
- **Tools** to help governments assess climate risks and vulnerabilities, and decide among policy options. Some tools, such as hazard mapping, may be in place already, but need to be customized to support adaptation planning and policymaking; others will need to be created to meet the challenges and uncertainties that lie ahead.

Some countries are already making an impressive start in addressing these elements and accounting for climate risks. Others, however, are just beginning to grasp the enormity of the challenge—even as they are dealing with the pressing demands for energy, jobs, education, and health care.

We hope this report can offer guidance for policymakers in countries around the world as they begin to address climate change risks—but particularly in developing countries. Although no country is unaffected by climate change, we know that countries will not be impacted evenly or to the same extent: some are vulnerable simply because of geography, while others will have to deal with climate change on top of existing economic and social vulnerability. Developing countries will bear the brunt of climate change and its costs, and the poor will suffer the earliest and the most from its effects. The economies of these countries, in large measure, are dependent on sectors such as agriculture and forestry, which are most susceptible to weather changes.

Climate change will test the ability of governments to lead, as never before. Trade-offs will be necessary in the choices policymakers must make—between the urgency of today's problems and the need to prepare for future risks. But how governments and societies make these choices will define how they adapt to a changing climate, and shape the world in which our children and grandchildren live and thrive.

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EXECUTIVE SUMMARY

ADAPTATION TO ACCOMMODATE CLIMATE CHANGE WILL FRAME the future for countries and communities across the globe. Responding to climate impacts as diverse as altered rainfall patterns, more frequent or intense extreme weather events, and rising sea levels will challenge decision makers at every level of government and in every sector of the economy. What steps should be taken to protect vital infrastructure, such as roads, dams, and factories, or to ensure the safety of housing stocks, both existing and yet to be built? What policies should be adopted or investments made to help agriculture adapt to new rainfall and temperature regimes and to secure local food supplies? How should valuable ecosystems like forests or coral reefs be managed to maintain the vital services they render and livelihoods they support? How can we ensure that the unique challenges faced by the most vulnerable and disadvantaged people are not overlooked or ignored?

Complicating these challenges is the uncertainty that surrounds how such changes will unfold. Future rainfall projections for Ghana in 2050, for example, vary from much wetter to much drier, with estimates ranging from a 49 percent increase to a 65 percent decrease from 2010 levels[1] in annual precipitation. Such a range makes it difficult for governments to prepare for the impacts on key sectors such as agriculture and electricity generation.

Another challenge that decision makers will need to face is that climate change will not play out on a level playing field. The vulnerability of affected populations and ecosystems will influence the outcomes of climate change on the ground. When a disaster strikes or a long-term change unfolds, the impact will vary between and often within regions, countries, and localities, based on the vulnerability of affected people. For example, a cyclone in Australia will not have the same impact on communities as one of equal magnitude in Bangladesh.

While there are early examples of adaptation efforts now taking place, many national governments have yet to integrate climate change risks into current and long-term planning and policy-making. Developing countries face particularly difficult challenges in doing so. Many will bear a heavier burden of climate change impacts because of factors beyond their control, such as geography. At the same time, their ability to undertake adaptation initiatives to accommodate long-term impacts, such as glacial melt or sea level rise, is severely constrained by the press of meeting current development needs, among other factors. Yet integrating climate risks into governmental decision making will be essential if development and other goals are to be met.

Rainfall projections for Ghana in 2050 range from much wetter to much drier.

DECISION MAKING FOR A CHANGING CLIMATE: OUR FOCUS

World Resources 2010–2011 is a joint publication of the United Nations Development Programme, the United Nations Environment Programme, the World Bank, and the World Resources Institute. It focuses on how national governments, particularly those of developing countries, can make effective decisions in a changing climate.

The ways in which governments anticipate and respond to the short- and long-term risks posed by climate change can have lasting consequences on the future of their countries. Even though many adaptation activities are led and implemented by local governments and communities, national-level decisions play key roles in enabling local and private-sector adaptation efforts, especially by providing information and guidance.

Climate change will affect many sectors, including agriculture, electricity production, transportation, forest and land use, and water management. Climate change is not just an environmental problem; its impacts affect all departments of government. This underscores the need for a comprehensive response by government and for different approaches to decision making that respond to the unique nature of the climate challenge.

This publication explores five key elements—*public engagement, decision-relevant information, institutional design, tools for planning and policymaking,* and *resources*—that we believe will significantly strengthen the ability of national governments to make effective adaptation decisions. Our arguments for why decision makers should focus on these elements are based upon the results of a wide-ranging and interactive research program (see Methods Box on page 20). Over 100 adaptation experts, public officials, sector-based practitioners and civil society representatives, from more than 30 countries, contributed to our research effort.

Public Engagement

Because of the potential disruptions and trade-offs inherent in decision making in a changing climate, early and ongoing public engagement is essential to effective adaptation. Involving the public can help governments define adaptation needs, choose among various priorities, and define acceptable levels of risk. Governments will need to ensure that those affected by climate impacts and adaptation decisions fully participate in those processes.

Decision-Relevant Information

User-driven, sufficient, accurate, accessible, long-term, frequently updated, cost-effective and targeted information is essential to effective adaptation. This report argues that governments should step up efforts to collect and distribute such information in a usable form in order to make informed decisions.

Institutional Design

Coordination among national-level government agencies and with other stakeholders and institutions at local, sub-national, regional and international levels will be a prerequisite of successful climate adaptation efforts. In many countries, present planning for the risks posed by climate change is often divided among different ministries and lacks a coordinating authority. Furthermore, effective government leadership and the use of institutional mandates are necessary if the integration of climate risks into planning and policymaking processes is to be a high priority.

Tools for Planning and Policymaking

Both commonly used and more specialized decision support tools can help public officials make difficult adaptation decisions. They can be deployed, for example, to assess climate risks and vulnerability and decide among policy options. Some existing tools, such as hazard mapping, can be customized to serve adaptation planning and policymaking purposes by integrating climate risks and vulnerability into their use.

Climate change will affect many sectors including agriculture, electricity, transport, forestry, land use and water.

Resources

Adapting to climate change impacts will require a full array of resources over time, including financial, human, ecological and social resources. Governments and donors will need to make investments that account for the lifespan of projected long-term climate impacts. Developing countries urgently need to acquire the skills and capacity to implement adaptation plans, policies, and initiatives.

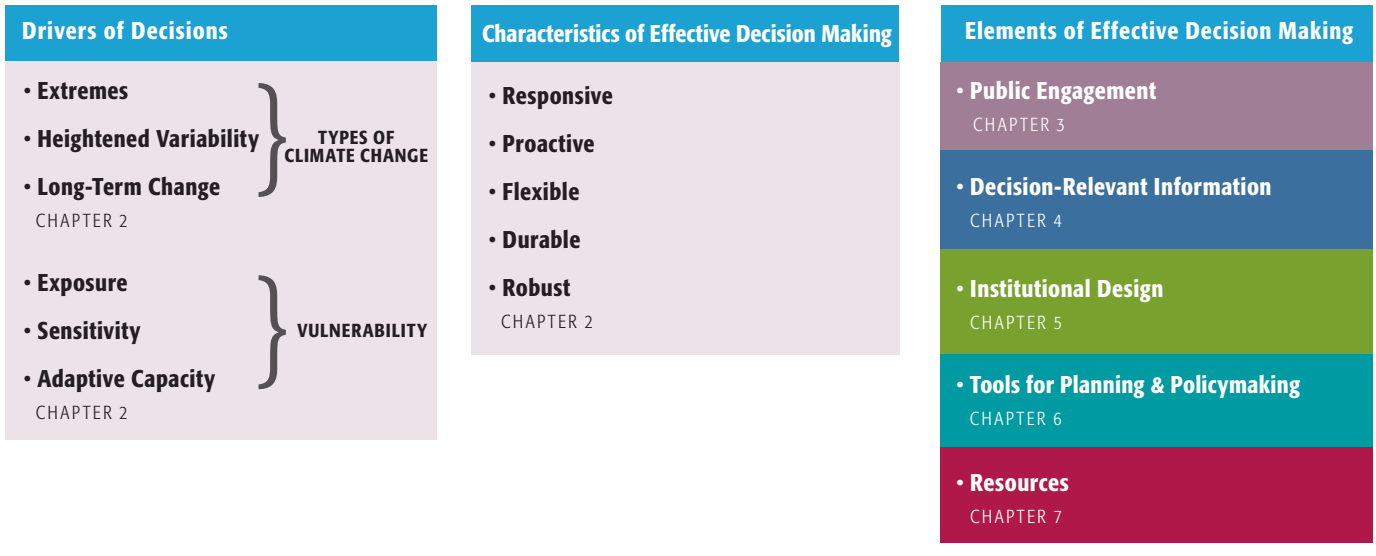
NAVIGATING THIS REPORT

We have organized this report in a manner that we hope will allow ease of access to the full range of information it contains. Figure E.1 is a navigational guide to the report. Chapter 1 gives an overview of the adaptation imperative facing decision makers. Chapter 2 describes some key types of challenges climate change will pose for governments—extreme events, heightened variability, and long-term change. It also describes the uncertainty surrounding the rate and magnitude at which impacts will take place across the globe. The Chapter then describes how climate change should be viewed and acted on in the context of the vulnerability of specific populations and ecosystems. Finally, Chapter 2 explores the characteristics of decision making—responsive, proactive, flexible, durable or robust—that will be needed, depending on the type of climate change being addressed.

Chapters 3 through 7 describe the five focus elements and why they are critically important to decision making in a changing climate. Each chapter provides examples of approaches that governments can deploy to bolster the resilience of communities and ecosystems.

The report also includes 12 case study summaries of national-level decision-making processes that already manage short-term and long-term risks (both climate and non-climate-related) within existing plans and policies, enabling us to draw useful lessons. These were commissioned from practitioners in Africa, Asia, Australia, Europe, Latin America, and North America working in sectors facing complex decision-making challenges: agriculture, electricity, coastal zones, water and forest management and land use. The complete studies may be found at *www.worldresourcesreport.org*.

Figure E.1 Navigating Decision Making in a Changing Climate



FINDINGS AND CONTEXT FOR RECOMMENDATIONS

As the following pages demonstrate, climate impacts are occurring already; they are not just concerns for the future. The pace, scale and scope of these impacts require different approaches to decision making. Climate extremes, for example, call for government policies and plans that are responsive to such events. Decision making will also need to be proactive if it is to effectively prepare for the occurrence of such extremes, as well as other types of climate change. Other types of change will require decision making to be flexible (to contend with heightened variability), robust (to withstand multiple scenarios in the future, given the uncertainty surrounding future impacts), or durable (to enable decisions to withstand long-term change).

Furthermore, the profound and far-reaching nature of the likely impacts of climate change will require decision makers to make extremely difficult choices. Given scarce resources, how is a decision maker to choose among competing priorities? For some adaptation decisions, planners and policymakers can take a stepwise approach, while always ensuring that short-term, "low regrets" decisions keep open future options as climate impacts unfold.

For other decisions, decision makers will need to take more aggressive action when making choices today that take future risks into account. This is especially true when planning long-term, expensive infrastructure projects, or taking other decisions that have long-lasting consequences. For example, the expansion of irrigation programs that depend on glacial water flows may need to be designed with future projections in mind, because that source of water may decrease in volume or shift in seasonality within a few years.

Finally, our research suggests that decision makers should be aware of and anticipate thresholds—points beyond which conditions or system performance can change dramatically—especially those thresholds having long-term, irreversible consequences, as they make adaptation choices. There are thresholds in natural systems as well as in man-made structures. The latter are easier to manage. For example, an existing flood control system may be effective against flooding from increased rainfall if it is understood when further action should be undertaken. Above a certain level of rainfall, additional improvements may be necessary or an entirely new system may be required that might also involve relocation of certain communities. Identifying such thresholds and building this knowledge into adaptation plans is one key method for improving adaptation decisions and outcomes.

Ecosystem thresholds, on the other hand, are far less likely to be evident until they have been breached. For example, wetlands may dry up in warmer temperatures as groundwater is depleted. Increases in temperature may encourage the invasion of woody plants into grasslands; the increased competition for moisture and nutrients could result in slow desertification.[2] Monitoring of ecosystem stress will be essential, as will further research into such thresholds. It will also be critical to take more aggressive action to protect such ecosystems, such as activities to restore ecosystems or limit their use.

The context for our findings, along with specific recommendations aimed primarily at governments and donors, comes from our research, which is laid out in Chapters 2 through 7, and explored further in the final chapter. The recommendations are organized by the five elements we have identified as key to effective adaptation decision making.

While readers may note that many of these recommendations would apply to many other public policy challenges, what calls attention to these elements and the accompanying recommendations is precisely the context in which they will be employed—the nature of climate change and its potential disruptive impacts. It is this context—decision making in a changing climate—that makes these elements and recommendations so important.

RECOMMENDATIONS

1. Public Engagement

Governments should convey to the public the scale and range of the risks, including known uncertainties, and expected impacts of climate change.

Many members of the public will not be aware of the risks climate change poses to their livelihoods and safety. Because of this, governments should provide targeted information on the risks facing various sectors, regions, ecosystems and communities. This will help build support for activities undertaken. It will take time for officials and communities to absorb the reality of having to accept some losses, such as the inability to grow certain crop varieties, and even longer to become comfortable entertaining alternatives, such as relocation of certain communities, that will disrupt entrenched patterns of society.

Governments should recognize that public engagement processes can lead to better decisions and should not be treated as "rubber stamps" on a pre-determined policy or plan. Policymakers should build opportunities for public engagement into all steps of the decision-making process.

Engaging communities can build support for difficult adaptation choices as well as improve the quality of outcomes achieved. Public engagement throughout the entire policy process often is necessary to ensure the effectiveness and long-term viability of a policy or an activity. Civil society organizations can help facilitate this exchange between government and the public.

Specifically, governments should recognize the public as a vital contributor when prioritizing needs, providing information, determining acceptable levels of risk, and choosing among and implementing adaptation decisions.

The public, including affected communities and experts, often are more aware than national-level government officials of the needs that exist locally, as well as what types and levels of risk communities are willing to accept. By consulting with the public first, decision makers can increase the likelihood that plans truly serve the needs of those who are affected by them. When the setting of adaptation priorities involves difficult trade-offs, public engagement can facilitate understanding of choices and their consequences.

Governments should ensure that those affected by climate change have legal rights to be consulted and engaged in policy and planning processes.

Those most vulnerable often are the least consulted and engaged in planning and policymaking. In some situations, those affected will not have a right to participate in governmental decision-making processes. Securing rights to participation is a critical step in enhancing public engagement. International treaties such as the Aarhus Convention and a growing number of national laws have codified such rights as access to information, public engagement, and to justice.[3] Legal mechanisms such as these can help empower communities in the decision-making process.

Given the potential for disruption resulting from certain adaptation decisions, it is important that all groups know and understand that they have been accorded rights to participate. Not all decisions will be able to accommodate the concerns of all groups, but governments should endeavor to make sure that all groups have an opportunity to express their views.

Decision makers should make use of innovative methods when engaging the public.

Innovations, such as the use of games and videos, and incentives, such as providing bicycles or cell phones to farmers gathering local climate information, can promote public engagement in adaptation efforts and increase chances of success. Government officials should learn from the effective use of these innovations elsewhere and examine how they can be implemented in their own country. Methods of engaging the most vulnerable should be tailored to their different circumstances.

RECOMMENDATIONS (CONTINUED)

2. Decision-Relevant Information

Governments should collect, analyze, and distribute decision-relevant information about climate risks and vulnerability as a basis for action. Information users must be engaged in determining needs.

Many developing countries lack the basic infrastructure and capacity to gather and distribute adequate, accurate, and user-friendly information necessary for decision making. Systems established for collecting and disseminating relevant information should respond to users' needs.

Information for adaptation planning and policymaking goes far beyond climate information; demographic, economic, social, and environmental information is also vital if actions are to meet the needs of those affected.

While most efforts related to adaptation focus only on climate-related information, non-climate information is needed to assess the vulnerability of regions, infrastructure and populations and to understand what decision options are available for both short and long-term climate impacts.

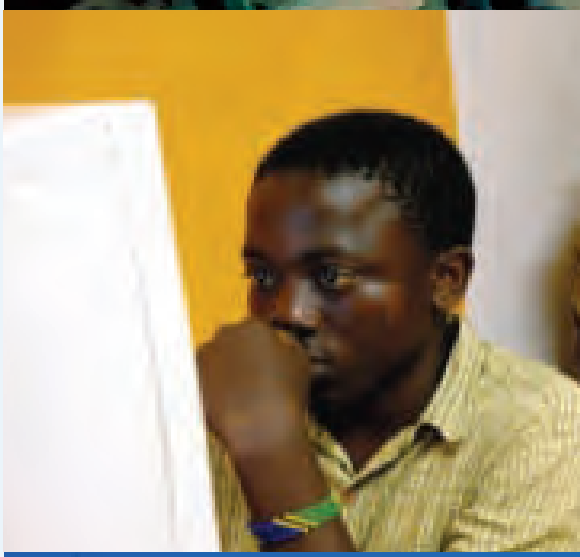
Governments and donors should establish and fund long-term and regularly updated information management systems.

Information for adaptation decision making may require new funding models to ensure the necessary scope, continuity and analysis of this information. Approaches could include the design of effective, two-way information exchange systems between governments and communities and investments into basic information-gathering infrastructure such as weather monitoring stations. Long-term donor support can help advance and maintain such systems, as can donor strategies to strengthen governments' abilities to maintain these systems on their own over time.

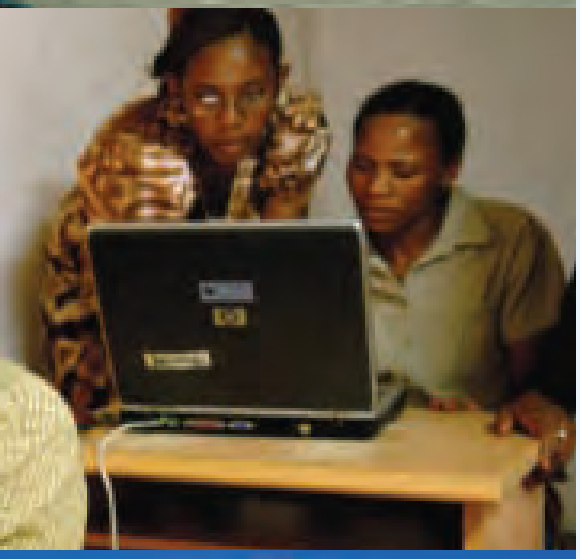
Governments should target information dissemination strategies to reach vulnerable populations that will be most affected by climate change.

Information must reach those affected in a form that makes it useful for decision making. Dissemination methods must at times be rapid, particularly in the case of extreme events. They should also be capable of reaching remote communities, which may involve scaling up, where appropriate, information and communication technologies including text messaging and satellite communications devices. This is an area ripe for donor and private sector investment.

The pace, scale and scope of climate change impacts require different approaches to decision making.



RECOMMENDATIONS (CONTINUED)



3. Institutional Design

Governments and donors should support the integration of climate risk management into ministries for economic development, finance, and relevant sectors, and they should consider appointing a dedicated central agency to coordinate all adaptation efforts.

Coordination among national agencies is critical to delivering effective responses to, and preparation for, climate change. Clear and effective coordination and communication is also essential between national agencies and local governments. Donors can greatly assist adaptation efforts by providing capacity building and technical support for coordinated approaches among national agencies and across all levels of government.

Governments, donors, and civil society organizations should cultivate and reward strong leadership.

Governments, donors and civil society organizations can and should foster leadership at all levels through appointments and incentives, as the choice of agencies and individuals to take the lead on adaptation can make a significant difference in whether adaptation activities are prioritized and implemented effectively.

Governments should reform institutional mandates to better contend with climate risks.

Mandates to integrate climate risks into decisions will likely be required. This is especially true for long-term risks that would not typically be considered in plans and policies. For example, national funding to local or regional governments for road construction and improvement projects could be dependent on a mandate that all related projects include an assessment of potential climate impacts and how they will be managed. Other mandates that may be required to address climate risks include those that are longer term to ensure ongoing consideration of climate risks, those that establish mechanisms for rapid response, and those that allow for continuous policy updates.

Governments should endeavor to make sure that all groups have an opportunity to express their views.

RECOMMENDATIONS (CONTINUED)

4. Tools for Planning and Policymaking

Planners and policymakers should integrate climate risks into existing decision-making tools.

As they begin to account for climate change in policies and plans, officials should deploy common tools, such as environmental impact assessments and economic cost-benefit analyses, modified to integrate the risks posed by climate change.

Decision makers should also seek out innovative tools that are especially useful for planning for short- and long-term climate risks.

There are a number of tools that are not yet standard in the policymaker's toolkit that could prove useful for adaptation, such as decision support maps, predictive instruments, and scenario planning and simulation exercises. These tools show promise for scaling up for more widespread application.

Effective use of tools will require training and capacity building.

Many decision support tools require specialized knowledge. Governments and donors should fund training programs that give practitioners the skills necessary to use these tools.

Clear and effective coordination and communication is essential between national agencies and local governments.

RECOMMENDATIONS (CONTINUED)

5. Resources

Governments and donors should provide targeted and sustained funding delivered through fit-for-purpose mechanisms that respond to the unique challenges of climate change.

Because climate change will evolve over decades, long-term financial support from governments and donors will be essential to maintain initiatives and infrastructure and to ensure a return on their investments. Fit-for-purpose mechanisms will be necessary to provide access to longer-term financial support for activities such as the continuous collection of adequate, basic weather and climate data. In addition, countries will need access to secure credit lines that can be tapped quickly for extreme events; they will also need to shift away from "hard" investments to those that build capacity, and support softer investments such as maintaining ecological climate buffers.

Current donor trends towards results-based lending may not facilitate such investments. A key challenge for donors and others will be to create incentives for developing countries to integrate climate risks into decision making, so that this integration is seen as an opportunity and not merely another claim on scarce resources. It will also be necessary for donors to strengthen government capacity to implement activities, and create a clear and appropriate exit strategy to ensure government ownership.

Donors and governments should promote and fund technical training and strengthen human resources, which will enable more informed decision making.

Developing countries urgently need to build the knowledge, staff, and technical skills among public officials that will enable them to integrate climate risks into existing decision-making processes. Those capacities are necessary to create, implement, manage, monitor, and enforce adaptation strategies.

Donors, governments, and the public should take steps to protect and maintain basic ecosystem processes that provide a crucial buffer for adaptation processes.

Ecosystems can mitigate many natural hazards. Maintaining them can be less costly than building expensive infrastructure, while providing more benefits to society. Donors and governments should fund ecosystem monitoring programs and should take proactive measures to ensure that critical thresholds within ecosystems are not overshot so as to protect the services they provide. Measures must also be taken to ensure that ecosystems themselves are resilient in a changing climate. Accordingly, their ability to enhance the adaptive capacity of human communities will not be diminished.

National governments should enable the development of social resources, which can play a crucial role in building the adaptive capacity of vulnerable groups and populations.

Activities such as extensive public engagement in the policymaking process and investment in improved communications platforms can build interconnectedness among communities. By providing opportunities for the development of such social resources, governments can facilitate coordination and cooperation among communities, enable opportunities for collective action to provide safety nets in times of crisis, and develop mechanisms to share other forms of capital.

CHAPTER 1

THE ADAPTATION IMPERATIV

CLIMATE CHANGE WILL FRAME THE FUTURE FOR COMMUNITIES across the globe. Responding to climate impacts as diverse as altered rainfall patterns, more frequent or intense extreme events, or rising sea levels will challenge decision makers at every level of government and in every sector of the economy. What steps should be taken to protect vital infrastructure such as roads, dams, and factories, or to ensure the safety of housing stocks—both existing and yet to be built? What policies should be adopted or investments made to help agriculture adapt to new rainfall and temperature regimes and secure local food supplies? How should vulnerable ecosystems like forests or coral reefs be managed to maintain the vital services they render and the livelihoods they support?

The decisions made to address these questions will influence the trajectory of growth and development in communities and nations for years to come. Yet such decisions are rarely straightforward, and often contentious. Their difficulty is compounded by the complexity of natural systems and national economies, by the uncertainties inherent in projections of climate impacts, and by the diversity of stakeholders the decisions must serve. It is not surprising, then, that many governments are unsure how to approach adaptation-related decisions in a manner that meets environmental, economic, and social challenges both efficiently and fairly.

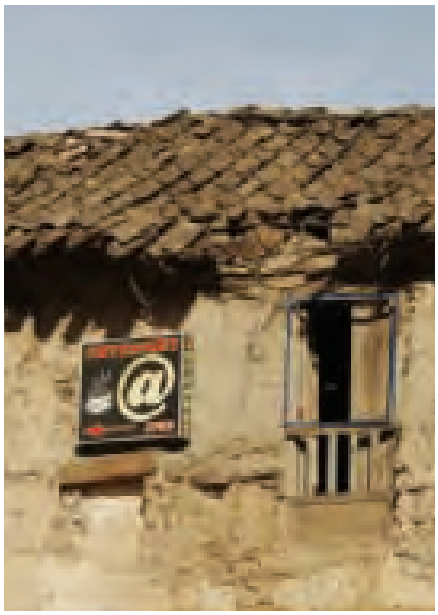
World Resources 2010–2011 addresses the difficulty of, and pressing need for, adaptation decision making. It analyzes current decision-making practices, acknowledging the inherent challenge in anticipating and responding to both short-term and long-term climate change risks in national policies and plans. It then focuses on how national governments, particularly in developing countries, can adapt to climate change by integrating climate risks into current practices in an effort to increase the resilience of their communities and ecosystems.

World Resources 2010–2011 examines five key elements of successful adaptation decision making:

- **Public Engagement:** How can public understanding, support, and active participation in adaptation be catalyzed?
- **Decision-Relevant Information:** What kinds of information are required to promote public understanding, support sound policies, and guide successful adaptation on the ground, and how should this information be collected and disseminated?
- **Institutional Design:** How should the structure, mandates, and processes of government agencies and other relevant institutions change to better plan for and support climate adaptation?

- **Tools for Planning and Policymaking:** What planning, assessment, and analytical tools are available to help decision makers understand climate-related risks and vulnerability and choose among available adaptation options?
- **Resources:** What financial, human, ecological, and social resources will be required to craft and successfully implement adaptation plans, policies, and initiatives?

To inform its consideration of these five crucial aspects of adaptation decision making, *World Resources 2010-2011* engaged leaders from around the world to learn about efforts already under way to address climate change. More than 100 adaptation experts, public officials, sector-based practitioners, and civil society representatives from more than 30 countries took part in this effort—one of the largest collaborations to date aimed at deriving critical lessons for strengthening and scaling up adaptation efforts. This research— available online in its entirety at *www.worldresourcesreport.org*—comprises a considerable archive of more than 50 expert papers and commentaries, as well as the proceedings of several decision-making simulation exercises and roundtables. These insights form the core of the analysis and guidance presented here. In addition, 12 case studies from around the world illustrate many of the report's findings and give examples of innovative approaches, policies, and practices.



URGENCY OF ADAPTATION

Interest in adaptation to climate change impacts has surged in recent years, driven by both advances in climate science and real-world events. The world has recently witnessed a series of weather events so extreme that they are at the limits of modern human experience. In the summer of 2010, one-fifth of Pakistan was flooded, affecting 20 million people, inundating thousands of schools and health centers, and destroying 2.2 million hectares of crops. At almost the same time, a record heat wave in and around Moscow led to more than 10,000 deaths and extensive peat bog and forest fires. Roughly one-third of Russia's grain was lost, driving up food prices worldwide. In early 2011, torrential flooding submerged an area of Australia the size of France and Germany combined while downpours in Brazil triggered mudslides that killed more than 600 people, one of the country's deadliest natural disasters on record.

Box 1.1 A Hotter Tomorrow

The world is quickly moving toward a much hotter tomorrow. Global average surface temperatures in 2010 were tied with the warmest on record, despite the presence of a strong cooling La Niña.[7] Since the 1880s when the industrial era began to trigger large-scale releases of emissions to the atmosphere from the use of fossil fuels, global average surface temperatures have risen by 0.8 degrees Celsius (1.5°F).[8] As a result, the world is already witnessing significant changes in its physical, hydrological, and ecological systems. Even if atmospheric greenhouse gas concentrations were to be stabilized today, the Earth would continue to warm an additional 0.6 degree Celsius due to the thermal inertia of the oceans. Thus, there would still be significant changes to contend with.[9]

Under the auspices of the UN Framework Convention on Climate Change (UNFCCC), the international community is beginning to implement greenhouse gas mitigation targets and actions. A recent assessment by the UN Environment Programme (UNEP), however, suggests that by 2100 the global average temperature will have risen between 2.5 and 5 degrees Celsius (4.5˚F-9˚F) over pre-industrial levels, even if all the emissions cuts pledged by countries associated with the Copenhagen Accord and inscribed in the Cancun Agreements are fulfilled.[10] If these emissions reduction pledges are not honored, or are not successfully implemented, the average global temperature could be much higher.[11]

Importantly, this rise in temperature will not be evenly distributed across the globe. Nor will the impacts of a changing climate fall uniformly on people, ecosystems and infrastructure in any particular region. The vulnerability of those affected, both within and between countries, will also determine outcomes. Those with greater exposure or sensitivity to climate impacts, or who have less capacity to adapt, will be most affected.

Disaster and extreme event preparation and response is a critical national capability, particularly in a changing climate, where the intensity or frequency of events such as heat waves and precipitation is expected to rise in many regions.[1] But the future under climate change will demand much more from governments, civil society, the public and donors as long-term changes transform global systems and cycles. Already, glaciers on every continent are melting[2] and doing so at a faster rate than seen in 5000 years.[3] Brazil, for example, has experienced torrential winter rainfall four years in a row, as well as two "100 year" droughts within five years in the western Amazon basin,[4] suggesting that this destructive weather pattern may soon become the country's "new normal." China is facing its longest drought in over 60 years, endangering its wheat crop.[5] Climate change promises to alter both the structure and function of ecosystems, thereby transforming the lives of hundreds of millions of people who depend on these critical life-support systems over large parts of the globe.

Complicating national government responses, much uncertainty surrounds how some climate impacts will play out. For example, projected rainfall change in Ghana by 2050 ranges from a 49 percent increase to a 65 percent decrease from 2010 levels, making planning for sectors such as agriculture and hydroelectric power highly challenging.[6] Uncertainty, however, cannot become an excuse for inaction. Instead, planning for and adapting to climate risks (see Map 1.1), with a focus on the most vulnerable members of society, will need to become a central priority of national governments in the near future.

While this might seem to be a daunting prospect, there is much we know already about actions that can enhance development while promoting climate resilience. Many of these are "low regrets" options that governments and donors might want to take for other reasons, such as planting mangroves to restore fisheries while also enhancing coastal protection. Others will require viewing development options through an additional climate lens. For example, urban planners might choose to expand coastal cities on to higher ground rather than along the coastline.

How governments make such decisions—the subject of this report—is critical to the well-being of both present and future generations. The world in a changing climate will be different, and governments must be able to respond effectively, fairly, and in ways that engage communities and protect the most vulnerable.

CHALLENGES TO PLANNING AND POLICYMAKING

Effective adaptation decision making will require a *significant shift* in how most governments currently plan for climate-related risks. Not only must countries improve their ability to foresee and react to extreme climate events, they must also plan for new patterns of local and regional climate variability, such as altered monsoon patterns, as well as long-term climate-driven changes, such as sea level rise. The combined effect of these profound physical changes could impact vast populations.

While scientists have greatly improved our understanding of climate impacts, the risks posed by climate change have yet to be systematically integrated into policymaking, planning, practices, and investments. This report argues that it is imperative that donors and governments start now to incorporate climate risks into economic development and ongoing planning and policymaking processes, especially in sectors such as urban development, coastal planning, agriculture, water and forestry management, and electricity production.

Incorporating climate change risks in decision-making processes is necessary to contend with the impacts on human well-being, species diversity, and critical functions performed by physical, hydrological and ecological systems. Moreover, if plans and policies do not do so, government and donor expenditures made explicitly to foster development may become less effective, failing to meet their goals.

In Pakistan, for example, it will cost hundreds of millions of dollars to rebuild the infrastructure and livelihoods financed by development aid to poor rural regions and then destroyed overnight in the 2010 floods. Taking into account future climate risks in the design and construction of that new infrastructure will be critical to meeting existing and future development goals.

In addition, while disaster preparedness is often the first step to address climate change, adaptation planning and policymaking focused on pressing short-term needs and emergency responses run the risk of failing to prepare for longer-term impacts, such as gradual changes in glacial coverage or sea level rise, that are likely to be even more devastating in their effect on agriculture, water supply and human habitation.

Although adaptation to climate change is the focus of this report, it is important to note that climate mitigation is also a crucial element of successful adaptation. As Box 1.1 describes, the world is quickly moving toward a much hotter tomorrow, necessitating substantial mitigation efforts. Governments must act together to swiftly and decisively reduce atmospheric greenhouse gas concentrations. Without such efforts to cut back on these emissions, some adaptation goals will be out of reach as the impacts will increase with every additional degree of temperature increase. Keeping adaptation efforts within an achievable range through mitigation is thus a baseline requirement for nations to succeed at adaptation decision making.

DECISION MAKING FOR ADAPTATION

In the developing world, which is expected to bear the brunt of climate change impacts, addressing the climate change challenge is somewhat eased by the fact that, in many instances, the priorities of adaptation and development are well aligned. One way of viewing the relationship between adaptation and development is to imagine them existing on the same continuum.[12] At one extreme, traditional development activities that bear no direct relation to climate can still reduce

Table 1.1 Summary of Case Studies

COUNTRY	SECTOR	DESCRIPTION OF CASE STUDY
Vietnam (PAGE 43)	Coastal zones	Mangroves have been planted along coastal areas to help provide storm protection for communities.
Nepal (PAGE 46)	Water	Nepal acted to prevent glacial lake outburst floods by installing an early warning system and lowering the lake level.
Namibia (PAGE 61)	Agriculture	Namibia has created community-based institutions and local-level monitoring tools to better support farmers living in communal areas prone to land degradation.
Mali (PAGE 64)	Agriculture	Mali's National Meteorological Service initiated a project designed to provide farmers with seasonal climate information.
Indonesia (PAGE 67)	Forest management / land use	A 2008 regulation in Central Kalimantan integrated the use of El Niño–Southern Oscillation information to assess future fire risk in deciding whether or not to allow farmers to use fires to clear land.
Brazil (PAGE 81)	Forest management / land use	A situation room was set up in the Brazilian state of Acre to process satellite data and coordinate the response to forest fires and floods.
Rwanda (PAGE 84)	Electricity	Rwanda implemented decisive actions in order to restore the ecological services provided by the Rugezi wetlands and prevent disruption of its electricity supply.
China (PAGE 87)	Agriculture/water	The Comprehensive Agricultural Development program has helped farmers in China's 3H Basin incorporate adaptation measures such as water-saving irrigation techniques and climate-resilient wheat varieties.
Bangladesh (PAGE 100)	Coastal zones	The Comprehensive Disaster Management Programme was set up to increase the nation's capacity to respond proactively to disasters.
China (PAGE 103)	Water	Efforts were adopted to combat flood risk by restoring floodplains and resettling farmers.
South Africa (PAGE 116)	Forest management / land use	Biodiversity information has been incorporated into spatial and development planning in South Africa, and a national strategy for expanding protected areas developed.
Mongolia (PAGE 119)	Agriculture	The Index-Based Livestock Insurance Project is intended to help herders cope with significant herd losses due to extreme events.

WRR EXPERT PAPER

BELAY BEGASHAW: "Adaptation, mitigation, vulnerability and resilience capacity are often referred to today in explaining the concept of climate change, its consequences to mankind, and how to respond to it. As a development practitioner from a poor African country, these terms and concepts are beyond resorting to jargon and rhetorical characterizations. Instead, they are an expression of the pain which millions of people are suffering from every day."
—Belay Begashaw, MDG Center

vulnerability to climate change; for example, a development strategy that increases income in poor communities also builds resilience and allows individuals to respond more readily to climatic shifts. At the other extreme, some activities respond directly to the effects of climate change and have very little to do with development. One such example would be the construction of a seawall to protect against a rising sea level. Numerous other instances fall somewhere in between these two extremes, in which a development plan or activity will need to incorporate climate risks and the vulnerability of those affected.

Indeed, some developing countries and communities are already beginning to integrate both short- and long-term climate risks into national development and sector-based planning and policymaking. However, while climate change impacts are already with us, adaptation decision making is still in its infancy. The case studies throughout this report give early examples of the integration of climate risks into policies and practices, as well as the lessons that have been learned so far (see Table 1.1). For example, Bangladesh has begun, with some success, to move from disaster relief to disaster preparedness through the development of pioneering early warning systems and education programs. Mongolia has established an innovative compensation scheme for farmers through index-based livestock insurance, providing a financial buffer for extreme weather events. Vietnam and China have undertaken efforts to restore natural landscapes to address climate-induced flooding. Governments in Mali, Namibia and Indonesia have all developed ways to enhance the exchange of decision-relevant information between the national government and local communities coping with shifts in seasonal weather patterns.

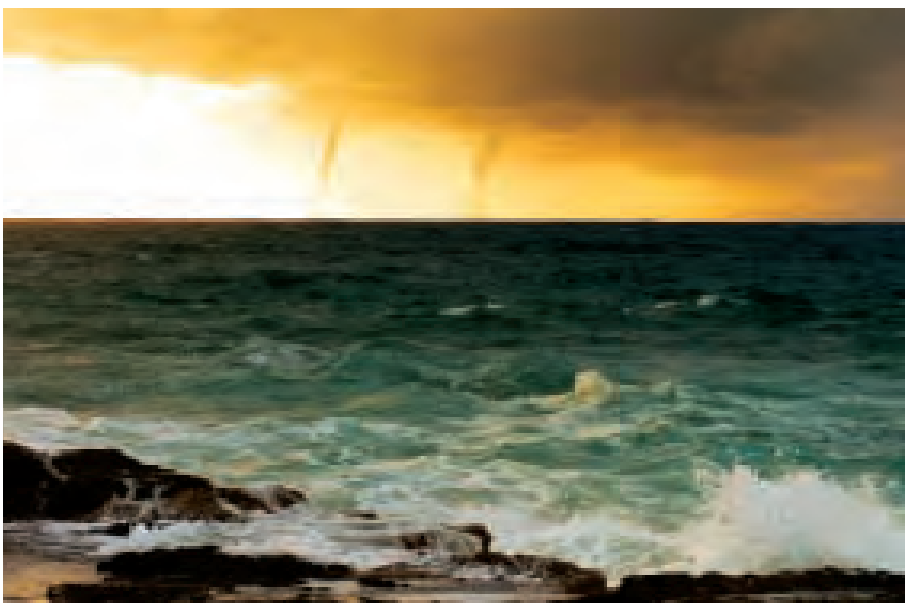
ADAPTATION DECISION MAKING: OUR FOCUS

World Resources 2010–2011 focuses on how national governments, particularly those in developing countries, can adapt to climate change by integrating climate risks into their current practices in an effort to increase the resilience of their communities and ecosystems. National policies and plans, especially those related to development, must be able to respond to and anticipate the short- and long-terms risks posed by climate change. The decisions that governments make to manage these risks will have lasting consequences for the future of their countries.

FIVE ELEMENTS OF EFFECTIVE DECISION MAKING

To this end, we devote the majority of *World Resources 2010–2011* to a discussion of five key elements, which have emerged from our research, that can assist decision making in a changing climate: public engagement; decision-relevant information; institutional design; tools for planning and policymaking; and resources, including human, financial, social and ecological resources.

As shown in Figure 1.1, this publication is organized around guidance in these five key areas that will strengthen the capacity of national governments to pursue effective adaptation plans and policies. The rationale behind each of these elements is summarized.



Public Engagement

Involving the public is the foundation of decision making for a changing climate. Public understanding of risks and solutions is essential for difficult national-level decisions on investments and priorities. Engaging the public can also help define adaptation needs, lead to better outcomes, and—given that financial and human resources are limited—inform government thinking on how to choose among various priorities and define acceptable levels of risk. At a local level, public involvement in planning and policymaking processes, and in implementing and monitoring initiatives, lays the groundwork for successful outcomes; lack of engagement can cause costly investments to fail.

Decision-Relevant Information

Useful information is the lifeblood of effective decision making, and this is particularly true for climate adaptation, given the uncertainty that surrounds future impacts. We argue that governments need to focus both on *what* types of information are required and *how* this information is collected, translated into a usable form, and distributed to all those who need it. The information required for planning and policymaking goes far beyond meteorological and other climate information. To identify and protect the most vulnerable people and ecosystems, governments must combine climate data with demographic, economic, social and environmental information.

Institutional Design

Climate impacts will reach every corner of society and every aspect of the policy arena, and the design of government institutions should reflect this reality. Coordination among national-level government agencies and with other stakeholders and institutions at local, sub-national, regional and international levels will be a prerequisite of successful adaptation efforts. In many countries, this will require a shift in both awareness and institutional alignment, since at present, the planning for risks posed by climate change is often divided among different ministries and lacks a coordinating authority. As we discuss in Chapter 5, the individuals and institutions who provide leadership in steering adaptation efforts can determine the effectiveness of interventions. In addition, institutional mandates can be reformed to better contend with different types of climate risks, such as the creation of long-term goals that are better suited to the timeframe of climate impacts.

Tools for Planning and Policymaking

Both commonly used tools, such as environmental impact assessments and cost-benefit analyses, and innovative tools, such as scenario planning exercises, can play a vital role in helping public officials navigate the complexities of decision making for a changing climate. They can be deployed, for example, to assess risks and vulnerability and decide among policy options. Some existing tools, such as mapping, can be customized to serve adaptation planning and policymaking purposes by integrating climate risks and vulnerability into their use.

Resources

Making societies and ecosystems climate-resilient will require financial, human, ecological, and social resources on a massive scale. Governments and donors will need to make long-term investments that mirror the decades-long lifespan of predicted climate impacts. Developing countries urgently need to build knowledge and technical ability among government officials to implement, monitor and enforce adaptation plans, policies and initiatives. Adaptation decision making should also place a premium on protecting and sustainably managing ecosystems, such as forests and wetlands, which can protect people from climate-related hazards as well as provide livelihoods. Finally, national governments should be proactive in developing social resources, such as those that enable communities to act collectively, cope with adverse conditions and show reciprocity and mutual support in times of crisis. These resources can play a crucial role in building the adaptive capacity of vulnerable groups and populations.

Figure 1.1 Navigating Decision Making in a Changing Climate

Drivers of Decisions

- **Extremes**
- **Heightened Variability**
- **Long-Term Change**

} TYPES OF CLIMATE CHANGE

CHAPTER 2

- **Exposure**
- **Sensitivity**
- **Adaptive Capacity**

} VULNERABILITY

CHAPTER 2

Characteristics of Effective Decision Making

- **Responsive**
- **Proactive**
- **Flexible**
- **Durable**
- **Robust**

CHAPTER 2

Elements of Effective Decision Making

- **Public Engagement** CHAPTER 3
- **Decision-Relevant Information** CHAPTER 4
- **Institutional Design** CHAPTER 5
- **Tools for Planning & Policymaking** CHAPTER 6
- **Resources** CHAPTER 7

ABOUT THIS REPORT

Figure 1.1 shows how *World Resources 2010–2011* is organized. Chapter 2 describes the three types of change associated with a changing climate and identifies key characteristics—responsive, proactive, flexible, durable, and robust—of effective adaptation decisions. The chapter concludes by highlighting the importance of vulnerability in determining outcomes on the ground, a critical factor that planners and policymakers will need to take into account when making decisions in a changing climate.

Chapters 3 through 7 describe in detail the five key elements that we believe can equip planners and policymakers to make more effective decisions. Finally, Chapter 8 presents our conclusions and recommendations.

National Government Focus

World Resources 2010–2011 focuses on how risks posed by climate change can be integrated into national-level government policies and plans, particularly those in developing countries. While governments do not work in isolation, and governmental outcomes are influenced by other actors and forces, we chose this approach for the following reasons:

- National governments play a key role in creating the conditions and support for local adaptation efforts.
- National-level policies define the priorities of sectoral agencies and inform sub-national strategies. Many development and poverty reduction strategies are also developed at the national level.[13]
- Governments create an environment that provides for the engagement of civil society organizations, scientists, and businesses in decision-making processes.
- A significant proportion of adaptation finance will go to national governments in developing countries, which will establish the priorities for spending, ideally in consultation with stakeholders.[14]

World Resources 2010–2011 focuses on developing countries, as they are the most vulnerable and will likely suffer the greatest impacts of a changing climate. However, many of our findings are applicable to both developed and developing countries. We also draw from experiences in developed countries throughout our research, insofar as they can be replicated in developing countries.

Table 1.2 Examples of Sectoral Decisions Affected by Climate Change

SECTOR	NATIONAL-LEVEL DECISION-MAKING PROCESSES	EXAMPLES OF KEY DECISIONS
Agriculture	National Agriculture Plan Crop Management Plan	• Choice between irrigation vs. rain-fed cropping • Introduction of new crop varieties • Relocation of farm communities
Energy	National Energy Policy/Strategy	• Choice of power generation • Choice to extend the grid vs. distributed generation • Siting of new power plants
Natural Resources Management	Coastal Zone Management Plan Forest Management Plan Protected Areas Plan National Invasive Species Management Plan Management Plans for Marine and Recreational Fishing	• Planning for endangered/protected species • Establishment of protected areas • Determination of maximum fish catch • Choice between hard vs. soft coastal protection measures • Control of disease, pests, and invasive species
Urban Planning / Infrastructure	National Transportation Plan Road Maintenance Finance Plan National Highway Plan	• Location of mass transit • Construction of bridges and highways
Water	National Water Policy Integrated Water Resource Management Plan	• Expansion of watershed restoration programs • Development of river basin cooperative agreement • Repair and redesign aging/leaking infrastructure • Enhanced flood control infrastructure
Tourism	National Tourism Plan	• Creation of ecotourism destinations
Cross-sectoral	Five-year National Development Plans National Adaptation Program of Action	• Identification of adaptation and development priorities • Prioritization of sectors and populations

Sector-Based Focus

Climate change affects numerous policy arenas, ranging from sectors such as energy, agriculture, forestry, water and transport (see Table 1.2) to overarching finance, development, economic growth, emergency preparedness, and security policies. The comprehensive nature of the response required is due in part to the far-reaching impacts of climate change, as well as its uncertainty, requiring complex planning and both short- and long-term decision making.

While cross-sectoral decisions such as tax, trade, and fiscal policies will play critical roles in shaping communities' ability to adapt to climate change, this report and its research base primarily focus on sectoral planning and policymaking processes,[15] as national goals will be made operational at the sectoral level, which is thus a key entry point for adaptation.[16] A key element of our research is 12 in-depth developing-country case studies of relevant policy processes in climate-sensitive sectors: agriculture, water supply, forest management / land use, coastal zone management, and electricity production. Many of the countries studied divide the responsibilities of government, and plan, at the sectoral level.

Focus on Policies and Plans

The attention of this report is focused on how governmental decision making, and specifically *policies* and *plans*, can be adapted to integrate risks posed by climate change—the difference being that a policy establishes approaches to meet certain objectives, while plans outline the decisions already made and the actions taken to implement policies.[17] The standard basic policy and planning cycle has been amended for the adaptation planning and policymaking process. For example, the U.S. National Academy of Sciences has outlined the following steps: identifying current and future changes, vulnerability and risk; developing a strategy, including the identification of opportunities and co-benefits across sectors; implementation; and monitoring and evaluation.

World Resources 2010–2011: Methods

New Model: For the past 24 years, *World Resources* has been published biennially in a collaborative effort by the World Resources Institute, UNDP, UNEP, and World Bank. *World Resources 2010–2011* is based on a new model that has engaged audiences both throughout our research activities and in developing the guidance for policy makers contained in this publication. Our research activities focused on identifying the elements needed for effective decision making in a changing climate. Findings and lessons learned are synthesized here, with extracts from our case studies and expert papers. The research can be found at *www.worldresourcesreport.org*.

Case Studies: 12 case studies were commissioned from practitioners in Africa, Asia, and Latin America working in sectors facing significant impacts and decision-making challenges:

- Coastal zone management: Bangladesh, Vietnam
- Water management: China, Nepal
- Forest management: Brazil, Indonesia, South Africa
- Agriculture: China, Mali, Mongolia, Namibia
- Electricity production: Rwanda

These studies provide examples of national-level decision-making processes that have integrated short-term and long-term risks into existing plans and policies, enabling us to draw useful lessons. Since many adaptation efforts are in their infancy, we also included case studies of processes that have succeeded in responding to or anticipating other types of change and may provide lessons for contending with climate change.

While any set of sectors will inevitably be arbitrary, we have chosen case studies in those listed above because decision makers in these sectors will face significant challenges in incorporating current and future climate risks in many nations, and because the list builds upon our partners' and our expertise. We include short synopses of our case studies throughout this report, interspersed between the chapters. For the complete case studies, please visit our website at *www.worldresourcesreport.org*.

Expert Perspectives: 56 expert papers and commentaries were commissioned from prominent public officials, thought leaders, practitioners, and WRR partner organizations in response to critical policy questions for adaptation decision making. These covered areas such as the role of donor agencies, civil society, and the private sector; information needs for effective adaptation; and whether a fundamentally different approach is needed to conserve ecosystems in response to climate change. Contributors from 36 countries took part in exchanges available on *www.worldresourcesreport.org*. The authors are listed on the inside front cover.

Uncertainty Paper Series: We commissioned several experts to write short policy briefs on how developing country decision makers can effectively contend with the uncertainty associated with climate change risks.

Simulation Exercises: In late 2010 WRR partnered with the Consensus Building Institute to host two innovative climate simulation exercises. The first in Accra, Ghana was co-hosted by UNDP and the Ghanaian Energy Commission. The participants included representatives from the Ministries of Energy and Finance and from prominent national non-governmental organizations. The second exercise, in Can Tho, Vietnam, was co-hosted by Can Tho University. The participants included government officials, representatives of farmers' unions and aid agencies, and scientists. We explore the outcomes of these exercises on page 98.

Roundtables on Information and Coordination: Two roundtables involving experts and practitioners informed our research. The first, held in Washington, DC, identified information needs and models for information collection and dissemination. The second, held in Cancun, Mexico, assessed emerging models for coordination and associated pitfalls.

Officials should also take an iterative approach to policy and plan development. This is essential since knowledge about risks, vulnerability, and priorities will change over time. Policy adjustments will also be required in line with new information, scientific developments, monitoring and assessment of strategies, and other policy processes (such as those related to mitigation).[18] Thus, the steps outlined above need to be carried out repeatedly, mirroring the long-lasting, changing nature of the risks posed by climate change.

Limitations

Our report describes interventions that countries have embraced to contend with the risks posed by climate change. We did not, however, perform a comprehensive assessment of adaptation options for any given type of climate hazard. Nor did we conduct an evaluation, such as with the use of cost-benefit analysis, of various interventions—an exercise conducted in many other studies.[19]

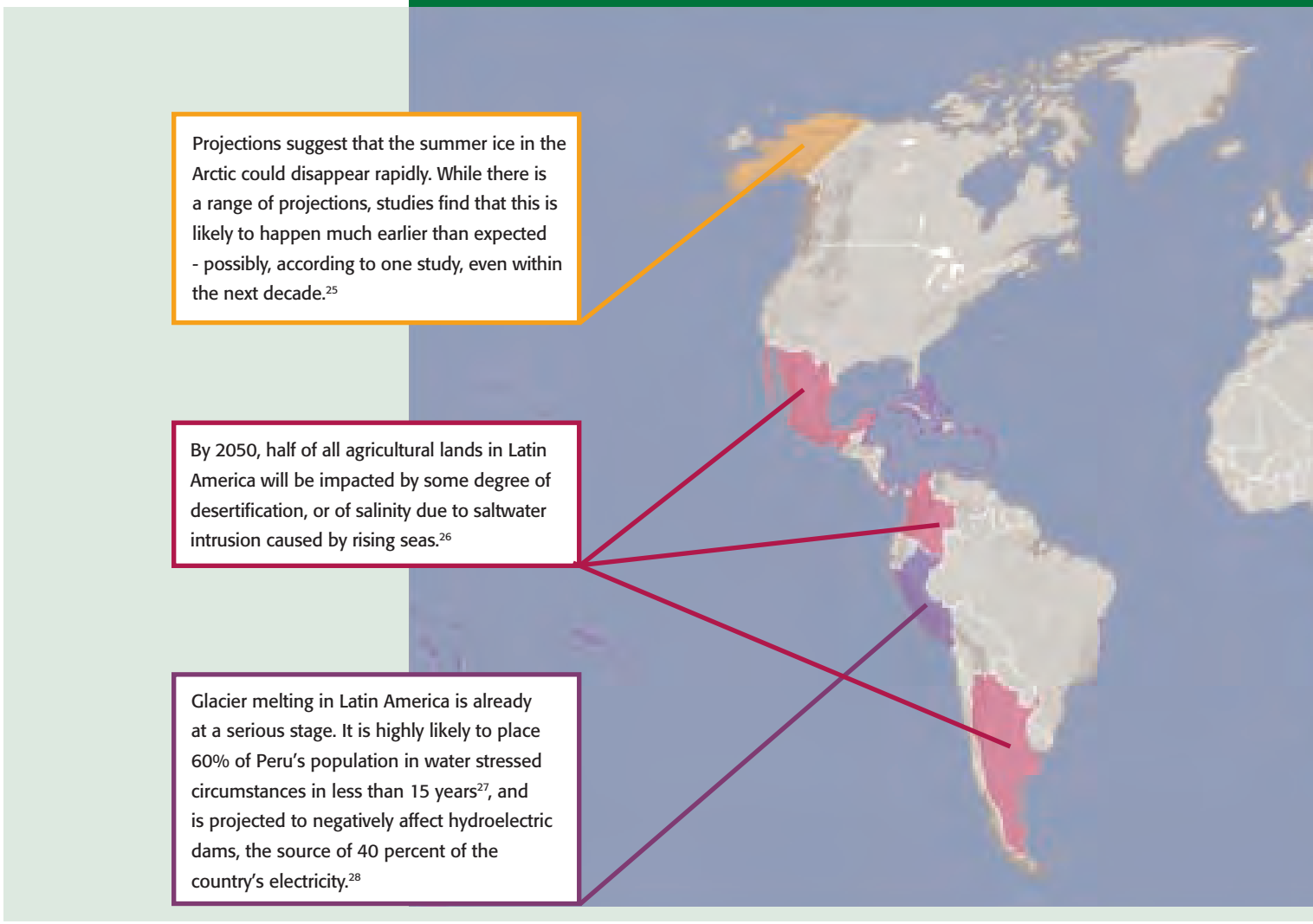
We acknowledge that some of our research findings may be context-specific and that there are limits to the comprehensiveness of the solutions presented. We also acknowledge the limits of our national-level focus. In some cases, the governance of climate risks will require different or additional measures beyond the integration of risks into ongoing national practices. Although national governments can play an important bridging role, many adaptation activities are led and implemented by local governments. Also, some national governments have power in the hands of too few and fail to engage civil society in decision making. Ethnic, religious, linguistic, and other identities may not correspond to national boundaries. A sole focus on national-level decision-making processes may lead to maladaptation across borders, overlooking certain climate impacts and increasing exposure or vulnerability elsewhere.[20] In addition, the national level may not be appropriate for managing transnational resources. For example, ecosystems do not always lie within national country boundaries. Also, our sectoral focus should not detract from the need for high-level leadership roles from economic development and finance ministries, which we discuss further in Chapter 5.

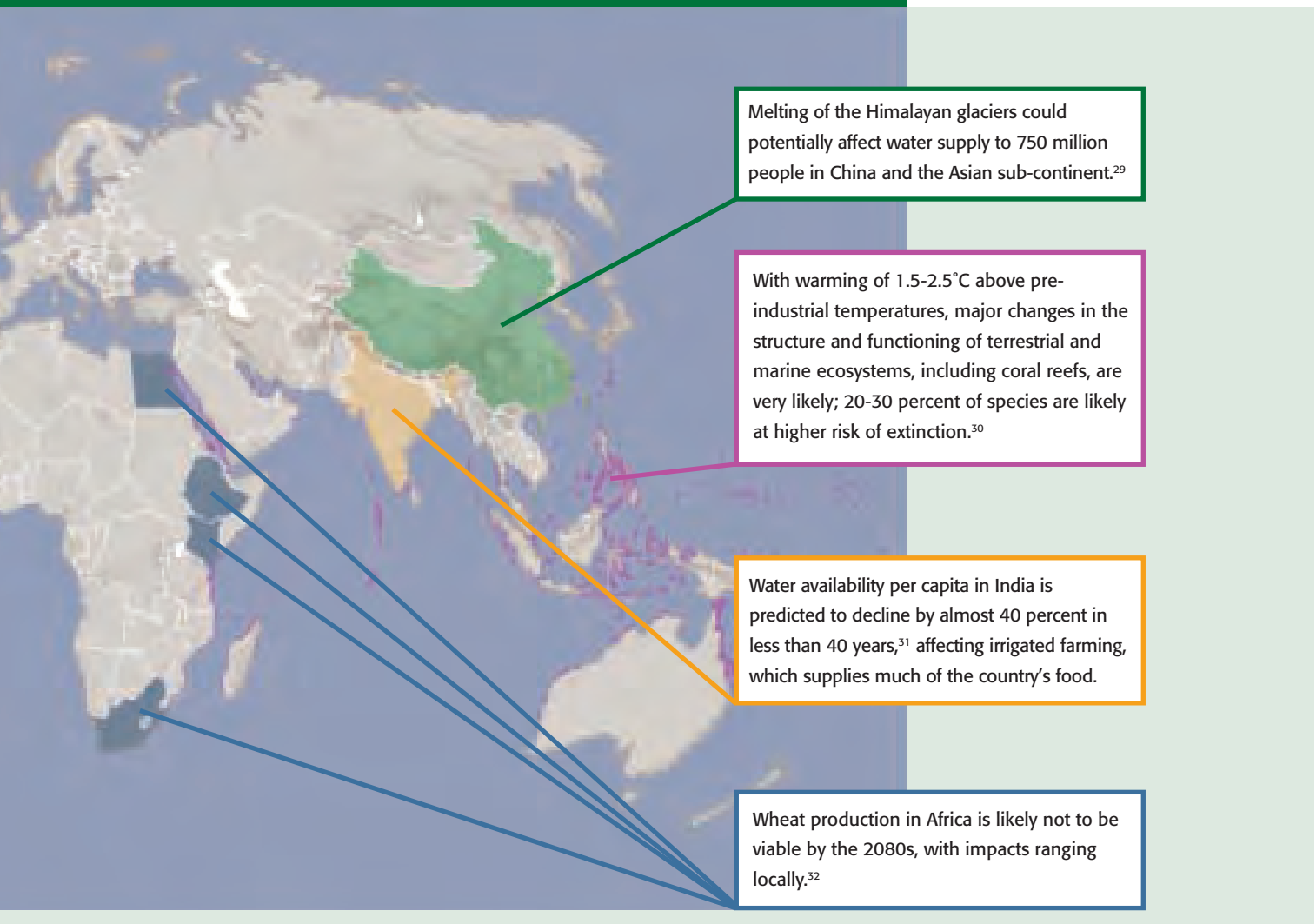
Many of the conclusions are drawn primarily from the research carried out specifically for this report. Proven examples of what works are few and far between, and monitoring and evaluation of outcomes is often weak.[21] The lessons we draw from our case studies can be highly context-specific. Likewise, Chapters 3 through 7 are not designed to give a comprehensive treatment of public engagement and other elements but, rather, to highlight useful lessons, examples, and options stemming from our research.

To complement our research, we assessed literature on adaptive governance,[22] uncertainty,[23] capacities and principles for adaptation decision making,[24] risk management, and decision-making tools for complex problem solving. We build upon this literature, with the hope of making it more accessible and concrete to planners and policymakers, highlighting detailed examples of how ingredients for more effective decision making can be realized on the ground.

It is our hope that this report provides insights that will enhance the capacity of governments to adapt to a changing climate.

Map 1.1 Future Climate Impacts





Climate change will frame the future for communities across the globe.

How governments make such decisions is critical to the well-being of both present and future generations

CHAPTER 2

CHANGE, VULNERAB DECISION M

CONSENSUS AMONG WORLD LEADERS IS GROWING THAT PLANNING for and adapting to our swiftly changing climate must become a central priority of national governments. But what does that mean, in practical terms, for planning and policymaking, and for the day-to-day business of government?

Do standard decision-making processes and practices need to change? And if so, how? Human society has historically found forward-looking, proactive decision making challenging. Our planning and policymaking processes are often slow to react to, learn from, and foresee change.[1] Existing planning processes tend to prioritize current risks, which is understandable given the pressing nature of hunger, lack of shelter, and other development needs. Accordingly, we tend to discount the future and to treat future costs and benefits as less important.

As Box 2.4 illustrates, however, climate change will present governments and the public with challenges that will require different attitudes and approaches to decision making. Meeting these challenges will involve balancing short- and long-term risks to a much greater extent than is common today and will necessitate weighing the trade-offs inherent in prioritizing adaptation activities. Decision makers will also have to take account of uncertainties related to climate impacts.

In this chapter we first lay out three aspects of climate change that public officials will need to contend with: more frequent or intense extremes; heightened climate variability; and long-term change. We also consider the uncertainty which surrounds all climate impacts. We then place adaptation decision making in the broader development context, exploring how the impacts of all types of climate change will depend on the vulnerability of affected populations, regions, and ecosystems. For example, a cyclone that strikes Australia will not have the same human, economic, and social impact as would a cyclone of the same severity that hits Myanmar or Bangladesh. Finally, we explore the characteristics of effective adaptation decision making. Based on our research, decision-making approaches that are *responsive, proactive, flexible, durable,* or *robust*, depending on the type of change involved, are most likely to succeed in the context of a changing climate.

BILITY, AND MAKING

CLIMATE CHANGES: EXTREMES, HEIGHTENED VARIABILITY, AND LONG-TERM CHANGE

Managing change is nothing new. Farmers try to anticipate and manage changes in production factors using available information about labor costs, scarcity of water, and crop markets.[2] Water resource managers plan allocation schemes with recent droughts in mind, recognizing that rainfall patterns can change.[3] Electricity-sector planners use projections of population and economic growth to calculate the future energy needs they are required to meet. Climate change adds yet another, but very different, layer of change to those that public officials are accustomed to addressing in the decisions they weigh every day.[4]

Decision making in a changing climate requires addressing three different types of change to the Earth's climate system: more frequent or intense *climate extremes, heightened variability,* and *long-term change* (see Boxes Boxes 2.1, 2.2, 2.3). Throughout this report, we trace how these types of change are likely to unfold and discuss the ways in which decision making for each, while often complementary, may also require separate planning and policy approaches.

In perhaps the most challenging scenario for policymakers, all three types of change can be present at the same time. India, the world's second most populous nation, faces such a prospect. The Intergovernmental Panel on Climate Change (IPCC) estimates that the Indian subcontinent will experience more intense rains over fewer days, triggering an increase in monsoon floods while at the same time the country is projected to suffer an overall decrease in rainfall. Projections also suggest that India will experience significant water stress by 2025.[5] Such circumstances create the potential for a cascading chain of impacts on vital resources such as water supply, for which public officials must prepare, especially in light of projected increases in water demand.

Extremes

A higher incidence or greater intensity of extreme events such as cyclones, intense rainstorms, and droughts is likely to be the most obvious sign of a changing climate. The impacts of extreme climate events are also likely to be the most immediately costly.[6] Deaths and damage to livelihoods, property, and infrastructure from disasters have risen in recent decades,[7] due to the combined influence of climate change, rising urbanization, and population growth, a trend that is projected to continue.[8]

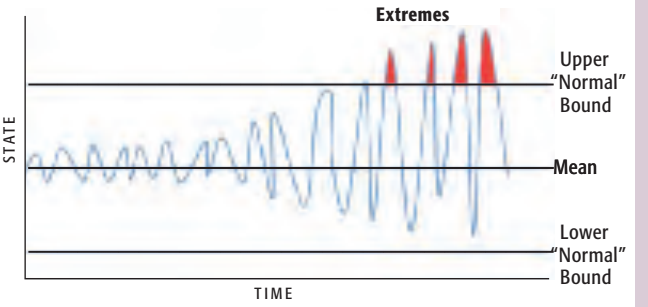
While extreme climate events may appear to be isolated phenomena, they are closely linked to both heightened variability and long-term change. In fact, changes in climate variability and/or the average state of the climate system can imply changes in the probability of extremes.[9] For example, changes in precipitation patterns can lead to more frequent or extreme droughts, severe flooding from rivers, and landslides. Changes in atmospheric pressure and sea level rise can lead

Box 2.1 What Is an Extreme?

According to the IPCC, "An extreme weather event is an event that is rare at a particular place and time of year. . . . By definition, the characteristics of what is called extreme weather may vary from place to place in an absolute sense. Single extreme events cannot be simply and directly attributed to anthropogenic climate change, as there is always a finite chance the event in question might have occurred naturally. When a pattern of extreme weather persists for some time, such as a season, it may be classed as an extreme climate event, especially if it yields an average or total that is itself extreme (e.g. drought or heavy rainfall over a season)."[10]

Depending on the type of extreme at hand, the exact definition of extreme can vary. For example, the IPCC defines heavy rainfall or snowfall events as exceeding more than 95 percent of the distribution range (whereas some events are defined as an extreme when exceeding more than 90 percent of the distribution range).

"Five percent sounds quite small. But translating this . . . into a gamble, the odds of extreme catastrophe are 1 in 20. . . . None of us would board an airplane that had a 1 in 20 chance of crashing. We would never buckle our children into car seats with a 1 in 20 rate of failure. While these are small odds at first glance, the downside is disastrous, making the chance unacceptably large."[11]

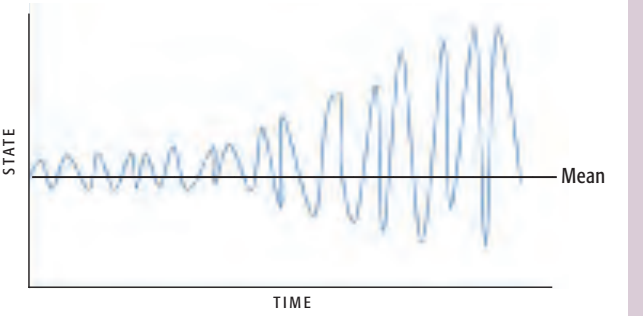


EXTREMES

- Cyclones
- Hurricanes
- Floods
- Wildfires

Box 2.2 What Is Heightened Variability?

Variability is seasonal, interannual, and decadal variations of the climate system. Heightened variability alters the rate, timing, and/or direction of natural cycles and extreme events.[12] For example, if a certain region previously could expect 25 to 40 inches of rainfall a year, under new climatic conditions, it might witness an altered range of 20 to 45 inches of rainfall a year. This seemingly small increase in variability can have major effects on water availability and crop yields, with implications for planning.



HEIGHTENED VARIABILITY

- Longer periods of drought
- Shorter rainy seasons
- Earlier spring onset
- Altered rainfall patterns between years

to extremes in the form of more severe ocean and coastal surges. And changes in temperature can lead to extremes in the form of more severe cold snaps or heat waves.[13] The latter scenario is already playing out across the world. According to the IPCC, the global average for cold days and nights, as well as for frost events, has decreased, while heat waves and hot days and nights have become more frequent.[14]

Heightened Variability

Aspects of the climate such as rainfall exhibit natural variability. Climate variability can occur over a single year, or over longer time periods such as one or more decades, and can play a significant role in determining seasonal precipitation and temperatures.

Many patterns of variability already exist, some better known than others. Examples include the El Niño–Southern Oscillation, circulation patterns over the western Pacific, inter-decadal variability over the North Pacific, the North Atlantic Oscillation, and the Atlantic Multidecadal Oscillation.[15]

Many people already account for some climate variability in their planning. For example, farmers know that there will sometimes be longer periods of dry weather during certain times of year and prepare accordingly. However, as the climate changes due to increased atmospheric concentrations of greenhouse gases, existing variability will be heightened in many regions as rainfall patterns are altered and growing seasons shift accordingly.[16] For example, some models project that the world may soon experience more permanent El Niño–like conditions.[17] This will mean that sea surface temperatures in some regions will warm more than in others. As a result, more intense rainfall events may occur between longer dry spells, resulting in a greater risk of floods. From a decision maker's perspective, heightened variability thus has implications for several key economic sectors, including agriculture, water supply, forestry, urban planning, and public health.

Long-Term Change

In addition to changes in climate variability, the average state of the climate system can also be altered by the buildup of greenhouse gases. Changes in average temperature, precipitation, and sea level rise, among others, can happen on both short and long time scales. This report focuses on long-term changes to the average state of the climate, as these arguably present the most difficult challenge to planners and policymakers, particularly given the short terms served by many governments relative to the time frames expected for such long-term impacts like sea level rise. While short-term changes to the mean state can be equally disruptive, for the most part they are captured in our discussion of climate extremes, since the climate changes that are most challenging in the short term are extremes.

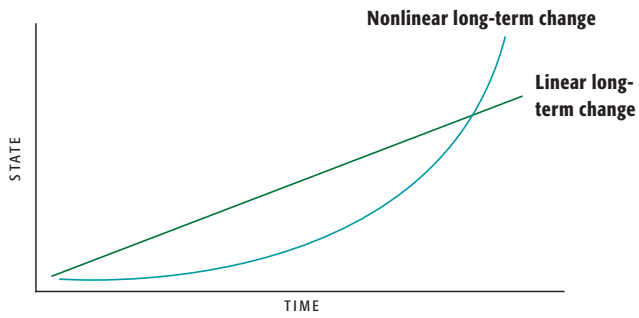
WRR EXPERT PAPER

SHARDUL AGRAWALA: "The stakes for both early action and inaction on the impacts of climate change are particularly acute in low income countries. Early action based on uncertain climate scenarios may impose significant opportunity costs to cash strapped governments simultaneously confronting more certain and pressing challenges. On the other hand, low income countries are also disproportionately vulnerable to the impacts of climate variability and change. . . . The economic and social costs of inaction may therefore be particularly high as well."

— Shardul Agrawala, OECD

Box 2.3 What Is Long-Term Change in the Average State of the Climate System?

In this report, we define long-term change in the average state of the climate system as a change in that climate system that persists for decades or longer.[18] We have used "long-term change" as shorthand throughout this report to convey this concept. Examples include a long-lasting change in temperature, sea level rise, rainfall patterns, or other parts of the climate system. These changes may require decision makers to take action well in advance of the change actually appearing.



LONG-TERM CHANGE

- Sea level rise
- Ocean acidification
- Sea ice and glacial melting
- Warming temperatures

Box 2.4 Adaptation Decision-Making Dilemmas

Decision makers in a changing climate confront significant challenges. This report seeks to provide guidance on how to respond to these challenges for national-level government officials working in sectors such as agriculture, water and forestry management, electricity production, and coastal zone management. The following are some illustrative examples of tough, real world choices facing developing country governments:

How should an energy planner in the Andes consider projected glacial meltwater loss when siting hydroelectric plants?

How should planners in West Africa—where the 500 kilometers of coastline between Accra and the Niger delta will have more than 50 million inhabitants by 2020—address the vulnerability of populations to sea level rise?[19]

How should forest managers in Amazonia choose among management strategies, given that 40 percent of the forests in the area could rapidly shift state with even a slight drop in precipitation?[20]

How are coastal planners in the Mekong River delta to contend with sea level rise, when projections show that one meter of sea level rise would inundate over 5 percent of Vietnam's landmass, with the delta south of Ho Chi Minh City being most severely affected?[21]

How can a water planner from a small island state in the South Pacific prepare for the effects of sea level rise and reduced rainfall on already vulnerable freshwater resources?[21]

The Earth's global surface average temperature has warmed 0.8 degrees Celsius, in the last century; the last 30 years has seen, an increase of 0.2 degrees Celsius per decade.[22] Daily minimum temperatures have risen at a faster rate than maximum temperatures, with associated changes in the number of frost days and length of growing seasons.[23] Sea level rise has accelerated both because seawater expands due to warming ocean temperatures and because of the loss of glaciers and ice caps.[24] The oceans have also become 30 percent more acidic compared to pre-industrial levels. This change has profound implications for marine ecosystems and for the human communities that rely on the services they provide. For example, the loss of calcifying organisms, such as coral reefs, which are harmed by increasing ocean acidity, will negatively affect the primary protein source of many coastal communities.[25]

There are some impacts of long-term climate change—for example, the loss of ice sheets and the impairment of ecosystem functioning—that are likely to be irreversible. For some populations, these impacts may not only be devastating, but have the potential to erase their identity. Small island states, for example, are among the least developed countries, and could become uninhabitable because of sea level rise. [26]

Even if these trends were simply to increase in a predictable straight-line fashion, planners and policymakers would not have an easy task. Yet recent science suggests that instead, impacts are accelerating in many parts of the global physical, hydrological, and ecological systems,[27] making planning even more difficult. Some of the changes now taking place, if not addressed in the near term, could result in significant and potentially irreversible change in a few decades.

In addition, changes taking place today could also potentially trigger feedback loops that in turn could accelerate future change. For example, feedbacks can be triggered by changes in how ocean ice cover reflects solar radiation from the sun. As the atmosphere warms, it heats and then melts the ice. While ice reflects solar radiation from the ocean's surface, open, uncovered water is darker than ice and therefore absorbs solar radiation. This can lead to further ocean warming and further ice loss, perpetuating the feedback and harming marine species.

WRR EXPERT PAPER

NICOLA RANGER AND SU-LIN GARBETT-SHIELS: "The consequence of not considering the uncertainty in future climate risks is to expose a society to maladaptation, where decisions are made . . . that are found to be unsuitable for the climate that occurs. Maladaptation can mean unnecessary, expensive, wasted investments and unnecessary, possibly irreversible harm to people and ecosystems."

— Nicola Ranger, Grantham Research Institute on Climate and the Environment and Su-Lin Garbett-Shiels, UK DFID

UNCERTAINTY

There is now significant consensus among scientists with regard to the role human activities play in climate change and the likely direction of many expected changes.[29] But there is still uncertainty with regard to the rate and magnitude at which the impacts will play out across the globe.[30] This uncertainty stands as a significant obstacle to timely and effective climate-related decisions. It can make decision makers unsure which path to take or can bias their judgment. Indeed, uncertainty is often used as an excuse not to integrate climate risks into plans and policies. For this reason, learning to account for and cope with this uncertainty is an important requisite for successful adaptation decision making.

Uncertainty about climate impacts stems from a lack of knowledge about key factors, such as:

- The magnitude of future global greenhouse gas emissions.
- The response of the climate system to these emissions.
- The scale and scope of climate impacts across regions and at the local level.
- The response of ecosystems to climate impacts and how this in turn changes the flow of ecosystem services.
- How climate change will interact with other drivers of changes in physical, hydrological and ecological systems, such as population growth; and
- What actions humans will take to both mitigate and adapt to climate change and how effective these will be in reducing vulnerability.

Uncertainties regarding climate impacts can have cascading effects (see Figure 2.1), compounding one another as well as the challenges facing decision makers. For example, the growth of greenhouse gas emissions will depend on population growth, economic growth, technological development, and energy use, as well as the kinds of climate mitigation policies that nations adopt and the changes in societies' behavior.[31] Additional uncertainties relate to the fact that there is not a one-to-one relationship between increases in atmospheric concentrations of greenhouse gases and the resulting increases in global temperatures. Rather, there is a range of probable temperatures that could result from a given concentration of greenhouse gases in the atmosphere.

As a result, governments must prepare for an array of possible climatic impacts that could play out in biological, hydrological, and physical systems. Moreover, the effect of these impacts will depend on social, political, economic, and ecological circumstances on the ground. Compounding this problem is the fact that uncertainty typically gets magnified over longer time spans.[32]

From the standpoint of decision makers, one of the most significant sources of uncertainty comes from the lack of resolution of global climate models at the local and national scales, the levels with which they are most concerned. While some models now attempt to depict changes on a local level, the majority of forecasts focus on a larger regional or global scale. Even if global average impacts could be accurately forecast, those impacts will be distributed very differently across the globe. For example, even with modest changes in global average temperatures, the poles are projected to experience a much more significant temperature change.[33]

VULNERABILITY

Climate change and its impacts will vary from location to location. The impact of each drought, cyclone, shift in seasonal rainfall, and rise in sea level will be determined in part by the vulnerability of the people and ecosystems in the location where it occurs. These differences in vulnerability—both within and between countries—stem from a wide range of social, economic, political, geographical, and ecological factors. As United Nations Development Programme's 2007/2008 *Human Development Report* acknowledges, "Climate risk is an external fact of life for the entire world. Vulnerability is something very different. It describes an inability to manage risk without being forced to make choices that compromise human well-being over time."[34]

Development efforts are already being undercut by extreme weather events such as the 2010 floods in Pakistan and by heightened variability, such as altered monsoon patterns, that affect crop production and livelihoods. In 2005 alone, drought threatened more than 14 million lives across sub-Saharan Africa.[35] Many affected communities are already vulnerable due to poverty, poor land management practices, and conflict, both within and between countries. Women are particularly

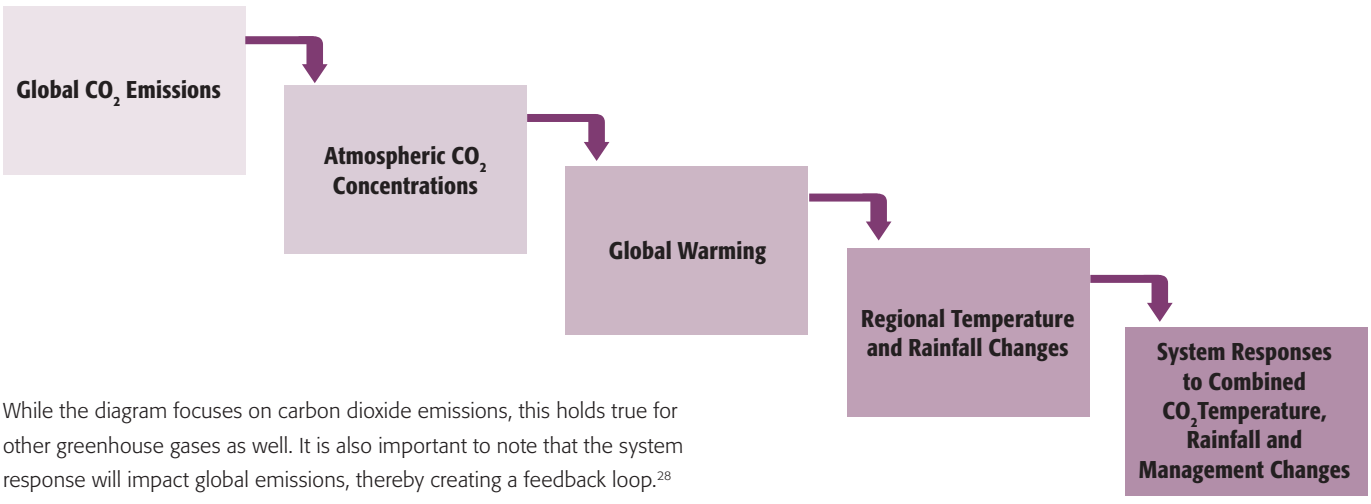
WRR EXPERT PAPER

MOHAMED EL-ASHRY: "Many low-income countries with populations at the greatest risk from climate change are already overwhelmed with existing public health challenges stemming from treatable conditions such as malnutrition, diarrhea, acute respiratory infections, malaria, and other infectious diseases. . . .

Diverting limited personnel and resources away from these ongoing problems to address future threats from climate change could make things worse instead of better. However, if the international community makes a serious commitment to help lower-income countries adapt to the health threats from climate change through improving basic health services, it will also help those countries address challenges that have been an ongoing scourge to their economies and their people."

—Mohamed El-Ashry, UN Foundation

Figure 2.1 Cascading Uncertainties



While the diagram focuses on carbon dioxide emissions, this holds true for other greenhouse gases as well. It is also important to note that the system response will impact global emissions, thereby creating a feedback loop.[28]

Box 2.5 Women, Vulnerability, and Climate Change

Women make up two-thirds of the world's poor[36] and comprise the majority of the workforce in those sectors, such as agriculture, that are particularly vulnerable to climate change. As a result, they are more susceptible to the impacts of a changing climate and may have few opportunities if those impacts cause their husbands to migrate in times of stress and leave them behind. This can lead in turn to further poverty and exploitation, such as trafficking.[37] From a policymaker's perspective, assessing and responding to women's vulnerability is thus essential to the effectiveness of adaptation initiatives.

Gender inequality increases women's particular susceptibility to the impacts of climate change. Women can have limited power to engage in decision making and fewer opportunities for education and employment. They also commonly lack rights, such as the right to own property, to vote, or to receive equal pay.[38] For example, some land tenure laws make it difficult or impossible for women to own land and, in turn, for unmarried or widowed women to find a stable livelihood.

Conversely, measures taken to address women's vulnerability can strengthen societies' capacity to act in a changing climate. When revitalizing the 3H Plain, a major agricultural area in China, the Chinese government involved the nonprofit Home for Rural Women in providing background information about local climate trends to farmers and conducting training in climate-resilient farming practices, such as planting drought-resistant wheat varieties. Since more than 70 percent of the area's farmers were women, this approach was critical to the program's success (see China case study p. 87).[39]

Similarly, in a survey of rural households in South Africa, men generally said that the women in their communities were more adept at responding to climate events that threatened their livelihoods, due to their specialized knowledge of food preservation and agricultural practices.[40] By engaging and promoting these capacities, decision makers can simultaneously pursue adaptation and development, building resilience in communities while promoting the rights and equality of women.

at risk, as they typically have limited or no access to credit and land rights and are often marginalized, reducing their ability to adapt to changing circumstances (see Box 2.5).

It will be of critical importance for planners and policymakers in developing countries to consider differences in vulnerability among affected populations when designing interventions to reduce climate risks, as poverty and other aspects of vulnerability today will shape the outcomes of climate change tomorrow.

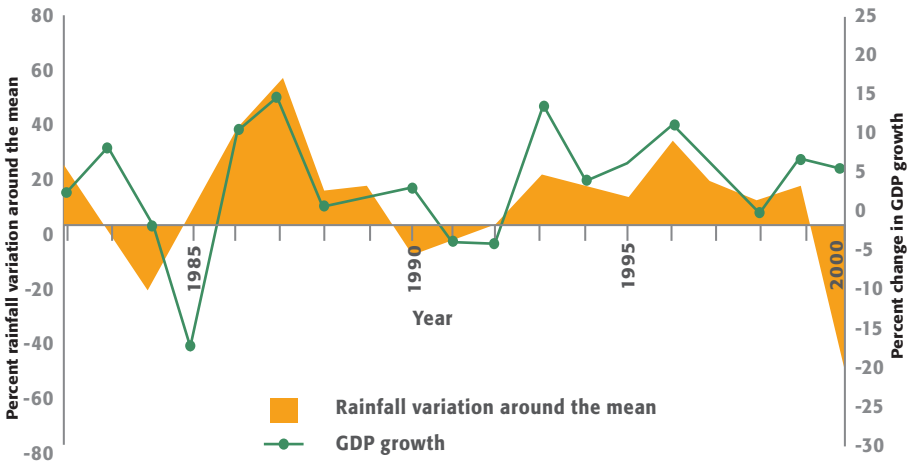
A community's or individual's vulnerability to a particular type of climate change will depend on three factors: exposure, sensitivity, and adaptive capacity.[41] These are, in turn, shaped by other elements, including gender, age, race, ethnicity, housing ownership, employment, family structure, education, and access to medical services.[42] For example, a household in a low-lying area of sub-Saharan Africa may be more exposed—and thus will be more vulnerable—to the climate-induced spread of a mosquito-borne disease than a community in the mountains where the disease has yet to spread. Within the broader low-lying community, however, the elderly and infirm might be more sensitive and may succumb to the disease more readily. On the other hand, those residents who have higher adaptive capacity, for example, transportation available to move to higher ground or money to buy medicine, are likely to be less vulnerable than those who have no viable options to leave the area.

Climate change can interact directly with other drivers of vulnerability, creating a chain reaction that limits the capacity of communities to build resilience.[43] A district facing food shortages can become more susceptible to disease as a result of malnutrition.[44] A flooded town may become more exposed to water-borne diseases, compromising labor productivity as people get sick.[45] Land that becomes uninhabitable can lead to displacement and the enforced sharing of often scarce natural resources. These heightened pressures can potentially result in conflict, for example, over disputed land and water supplies.[46]

Governments have little control over some drivers of vulnerability to climate change impacts, such as geography. Other drivers may result from public actions taken over many decades, such as poor land zoning and enforcement. For example, removing trees from hillsides because there are no alternative fuel sources can lead to soil erosion, which in turn can leave the area more vulnerable to mudslides in a storm.

In the next section we describe how the outcomes of the three types of climate change discussed above—extremes, heightened variability, and long-term change—are dictated by vulnerability. In so doing, we seek to underscore the critical need for planners and policymakers in developing countries to target their adaptation efforts at reducing vulnerability.

Figure 2.2 Gross Domestic Product (GDP) and Rainfall in Ethiopia



SOURCE: The World Bank. "Managing Water Resources to Maximize Sustainable Growth: A Country Water Resources Assistance Strategy for Ethiopia." 2005.

Extremes

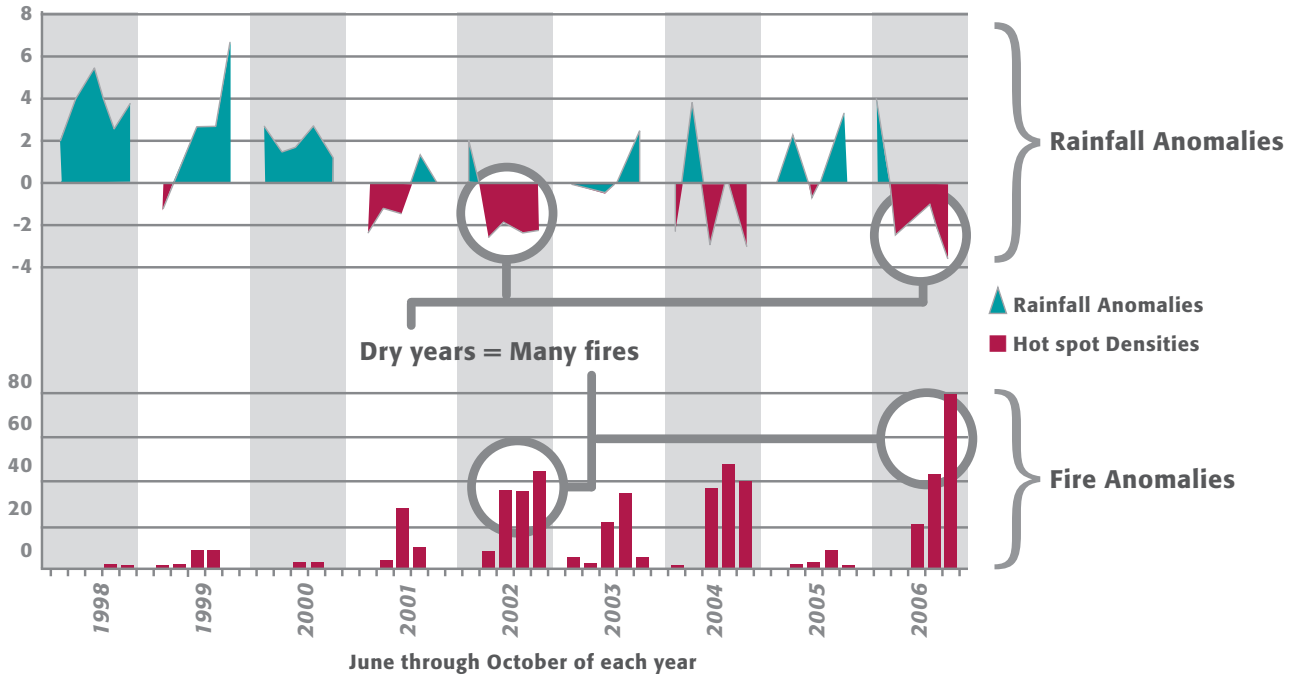
Existing vulnerability shapes the impacts of extreme climate events. The poor often lack savings and safety nets for cushioning against the havoc wreaked by cyclones, floods, and other natural disasters.[47] They therefore have far fewer options at their disposal and thus lower adaptive capacity. For example, since impoverished families and communities often have limited access to insurance, loans, and credit,[48] in times of adversity (such as the aftermath of an extreme event) they may need to ration food, sell off assets such as livestock, or remove their children from school. Such responses can have cascading effects, not only exacerbating vulnerability in the immediate circumstances, but also leading to longer-term vulnerabilities, such as chronic hunger and an uneducated population.[49]

Climate extremes can therefore significantly alter development paths, setting nations and communities back years or even decades.[50] According to the United Nations Development Programme (UNDP), "Single climate events can . . . create cumulative cycles of disadvantage that are transmitted across generations."[51] Repeated disasters can have an even greater effect, giving those affected little time to bounce back[52] and weakening efforts to alleviate poverty.[53] Ethiopia, for example, experienced several severe droughts between 1999 and 2004. Research suggests that if the stricken communities had had more time between these events to recover by building up assets and borrowing, the rate of poverty in these communities would have been 14 percent lower in 2004.[54]

Heightened Variability

The ways in which heightened climate variability manifests itself on the ground are also determined by vulnerability. Communities highly dependent on climate-sensitive ecosystems or economic sectors—agriculture, for example—are often more vulnerable to heightened climate variability, such as altered rainfall patterns. Figure 2.2 illustrates how GDP closely mirrors rainfall patterns in Ethiopia, where rain-fed agriculture is of critical importance to jobs, livelihoods, and food security.[55] Similarly, farmers have traditionally employed fire to clear land in Central Kalimantan, Indonesia, because there are few alternatives; the practice can lead to devastating forest fires in years when rainfall is less frequent, a pattern that in turn depends on sea-surface temperatures and the El Niño–Southern Oscillation (ENSO) cycle (see Figure 2.3).

Figure 2.3 Consequences of Rainfall Anomalies on Fire in Central Kalimantan



Rainfall data: NOAA. CMAP and CMORPH. Hotspot data: NOAA. AVHRR and TERRA MODIS. Lead Scientist: Dr. Pietro Ceccato (IRI/IPB, 2009).
Shiv Someshwar, IRI/Columbia University; Rizaldi Boer, Bogor Agricultural University; Esther Conrad, University of California at Berkeley, WRR Case Study

On the other hand, the role that climate-sensitive ecosystems play in determining vulnerability can be turned into an opportunity through measures that strengthen such ecosystems and provide other important benefits as well. Mangrove restoration programs in the south of Vietnam serve as buffers to storm surges while providing a hospitable environment for aquaculture enterprises to develop (see Vietnam Case Study p. 43).

Long-Term Change

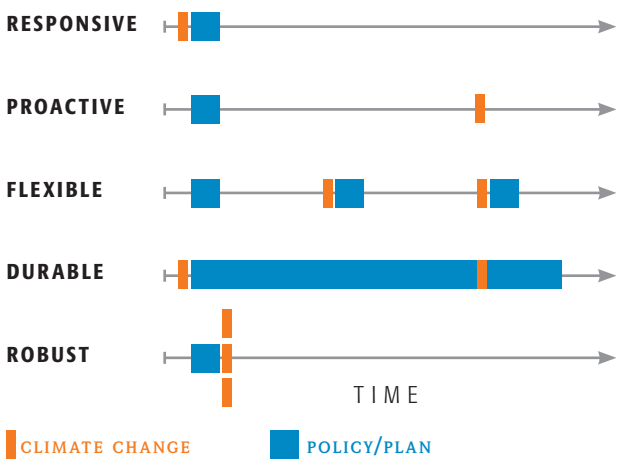
Underlying vulnerability can determine the outcomes of long-term change. For example, in many regions, water supplies are already scarce because of inefficient agricultural practices. Those supplies will be further stressed in a changing climate. This is especially true for the one-sixth of the world's population that depends on water supplied by glaciers and snow cover, which are projected to decline over the next century.[56] Longer-term changes will also include sea level rise, the effects of which may be profound for coastal populations and low-lying countries in Africa, Asia, the Americas, and the Pacific islands, whose geography makes them vulnerable. Thus, climate change impacts can also add to other stressors and, in so doing, exacerbate the vulnerability of both people and the ecosystems that supply their basic needs.

Today's fragile communities, when further stressed by climate change, may become increasingly dysfunctional, even leading to the breakdown of social order. Some communities may be forced to migrate if adaptation in a given location becomes impossible. Accordingly, climate impacts borne by one community can quickly turn into regional—and even global—impacts as people and species migrate. As the UN High Commissioner for Refugees recently stated, "Through its acceleration of drought, desertification, the salinisation of ground water and soil, and rising sea levels—climate change too can contribute to the displacement of people across international frontiers."[57]

CHARACTERISTICS OF EFFECTIVE DECISION MAKING IN A CHANGING CLIMATE

Research conducted for *World Resources 2010–2011* suggests that the unique challenges presented by climate change will require decision-making approaches that display certain characteristics tailored to the types of changes, uncertainties, and vulnerabilities described here. In the short sections that follow, we explore the need for adaptation decision making to be responsive, proactive, flexible, durable, or robust, depending on the type of change at hand. Decision making that exhibits these qualities is more likely to be able to assess climate risks adequately, formulate plans that can accommodate uncertainty, and stand the tests of time and public acceptability. These five characteristics of the types of decision making needed in a changing climate are by no means exhaustive, however. A broader suite of principles of good governance will also be essential if adaptation decision making is to be effective and target the most vulnerable.[58]

Figure 2.5 Five Attributes of Effective Decision Making for a Changing Climate



FIVE CHARACTERISTICS OF EFFECTIVE DECISION MAKING

The Need for Responsive Decision Making

RESPONSIVE

A responsive decision-making process would advance POLICIES/PLANS *after* a CLIMATE CHANGE has occurred, to react quickly to the CLIMATE CHANGE.

In dealing with the aftermath of extreme events, decision-making processes will need to react quickly to information about the impacts on people and ecosystems caused by the event. Ideally, over time, governments can move from responsive to proactive decision making—from disaster relief to disaster risk reduction and preparedness. Bangladesh, one of the world's most natural disaster-prone countries (see p. 100), provides a good example of such a progression in national policy.

The Need for Proactive Decision Making

PROACTIVE

A proactive decision-making process will create POLICIES/PLANS in advance of a CLIMATE CHANGE that has yet to occur; the decision-making process prepares for that CLIMATE CHANGE and its impacts.

Because of the cumulative nature of climate change and its long time horizon, the need to anticipate and act on climate risks early is especially pressing. Seemingly incremental climate changes today that are not abated in the near term could manifest themselves decades from now as potentially irreversible changes. Examples could include the loss of glacial ice sheets, unique cultures, and species diversity, or the collapse of certain biological, physical and hydrological systems.[60]

Thus, decision-making processes must be proactive—anticipating extremes, variability, and long-term change and their consequences—if development and environmental goals are to be met. For example, a planner may choose not to locate new hydroelectric dams in an area that models show may be subject to drought in a decade.

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SALEEMUL HUQ: "Floods, droughts and hurricanes are well known phenomena which affect many parts of the world. However, preparing for the increased frequency and/or increased magnitude of events is something we have only just started to think about (both at the global as well as national level). . . . The paradigm shift that is needed is to move away from the current reactive mode to a more proactive mode, or from disaster management (post disaster) to disaster preparedness (or disaster risk reduction)."

— Saleemul Huq, International Institute for Environment and Development

Box 2.6 Flexible Decision Making in Action

The following steps provide an example of a flexible decision-making pathway of the kind that planners could take as climate impacts intensify:[59]

A new bridge is built to withstand an expected one meter of sea level rise. It is constructed in a way that enables adjustments to be made later (e.g. bridge pylons can be raised if sea level rise is higher than currently estimated).

Long-term monitoring is put in place to track the climatic change (in this case, sea level rise).

If monitoring indicates that the change will be worse than planners envisioned (e.g. 1.5 meters of sea level rise is now likely), more aggressive action can be taken, such as raising the bridge.

Such an approach will be easier to implement if policymakers have:

- Knowledge about the threshold (or range of possible thresholds) of the decision (e.g. how much sea level rise the bridge will withstand).
- Access to long-term monitoring systems to evaluate change.
- Information about how much time is required to implement more aggressive action (e.g. it will take three years to raise the bridge), so that planners have enough lead time.

* For a description of how these steps were embraced in the Thames 2100 project, see Box 6.1.

The Need for Flexible Decision Making

FLEXIBLE

A flexible decision-making process adjusts POLICIES/PLANS based on ongoing CLIMATE CHANGES, with each response readjusted due to learning from previous experiences and new conditions on the ground.

As global average temperatures rise, conditions may change quite quickly—over days, seasons, and years. Decision making will need to be flexible, or adaptive, and be able to adjust to new information and conditions in order to account for the dynamism of a changing climate (see Box 2.6). As we discuss throughout this report, there are several ways to increase the flexibility of decisions, including provisions for regular revisions and through investments in continuous monitoring of changes on the ground. Depending upon the measures adopted, flexibility may or may not be costly. For example, building revision procedures into long-term plans might not be prohibitively expensive and would provide an opportunity to periodically reevaluate strategy.

The Need for Durable Decision Making

DURABLE

A durable decision-making process advances POLICIES/PLANS that can accommodate the long-term nature of some CLIMATE CHANGES.

Long-term changes in the average state of the climate will clearly put a premium on durable decision making that results in long-lasting decisions. This will require plans and policies to embrace long time horizons—beyond political cycles and the short-term policymaking this tends to produce. Durable decision making also will often necessitate commitments from donors to engage beyond the traditional project cycle; strong and committed government leadership will be needed as well. This could help decisions withstand changes that take place over a long period of time. We explore these requirements, and others, in the chapters on institutional design and information.

Durability does not necessarily have to be at odds with flexibility, although it would be intuitive to think that these characteristics are opposites. For example, it is possible to develop a 50-year plan with five-year revision processes, thus securing both long-term mandates and the possibility for ongoing changes in response to evolving circumstances.

The Need for Robust Approaches to Decision Making

ROBUST

A robust decision-making process would result in POLICIES/PLANS that are effective in managing a full range of possible impacts associated with a given CLIMATE CHANGE; that is necessary due to the uncertainty regarding the timing, scope and scale of some CLIMATE CHANGES.

Given the uncertainty surrounding how climate change impacts will unfold, robust approaches to decision making will be needed to maintain relevance and be effective under multiple climate scenarios. Robust interventions are those that will work under a range of climate conditions and will enable communities and ecosystems to prepare for and thrive in the face of a variety of possible risks. For example, a distributed electricity production system that relies on multiple sources of generation may withstand changes in rainfall patterns more easily than a hydroelectric dam of similar output, which could be vulnerable to extreme drought scenarios.

Decision-Making Characteristics

Decision making that reflects these characteristics will not always require reinventing the wheel. For climate extremes, in particular, much experience in advancing both responsive and proactive approaches already exists. Governments around the world have committed to improving their abilities to respond to and prepare for natural disasters, drawing on lessons learned.[61] And the international disaster management community is now advancing best practices for integrating climate risks and forging relationships with climate change adaptation experts.[62]

Risk management strategies, meanwhile, have increased the ability of countries to both reduce and transfer risk when dealing with extreme events.[63] For example, the Government of China dedicated over US$3 billion to flood control between 1960 and 2000. According to the World Bank, flooding during this time would have caused an additional US$12 billion in damages[64] without such measures. When preventive measures are not adopted (which is often the case), the development of contingency plans and policies can improve the response to disasters by putting systems in place for relief and recovery.[65]

A greater shift in current decision-making processes may be necessary for some other types of change. For heightened variability, flexibility is key. By adopting approaches that can adjust to changing circumstances and new information, policymakers and donors can do much to reduce the vulnerability of people and ecosystems to changes in seasonal and inter-annual climate cycles. Some specific examples drawn from our research, and described more fully in later chapters, include government investments in continuous and comprehensive updates of decision-relevant information that can be regularly incorporated into adaptation activities.

In preparing for long-term changes in the average state of the climate system, decision makers will need to balance the response to immediate concerns, including basic human needs, with the proactive preparation for likely future impacts (e.g. sea level rise) that necessitate early adaptation action (e.g. decisions on whether to strengthen coastal defenses). Many decisions taken today—especially those that are difficult to change, such as building infrastructure and instituting development policy[66]—will affect future generations' ability to contend with the long-lived effects of a changing climate.[67]

Decision makers will also have to contend with the uncertainties that surround climate change impacts. If societies fail to plan for certain impacts and to adopt robust measures to deal with them, investments could be wasted, and development goals undercut. Poor planning can also lead to negative and costly outcomes, such as building large dams to generate hydroelectric power in regions where rainfall levels might decline, or expanding cities along coastlines that may be vulnerable to sea level rise, rather than inland.

To avoid such outcomes, governments should design plans and policies to be robust under multiple climate scenarios. One way to address trade-offs between short- and long-term policy objectives and uncertainty is through incremental, adaptive policymaking that avoids both locking in future vulnerability and closing off options for more aggressive action should the need arise.[68] At a very basic level, for example, engineers can design bridges that can be raised should sea level rise eventually exceed their original estimates (see also decision route maps, Chapter 6). We discuss these and other solutions throughout the report.

The complexity of making effective decisions for a changing climate against a backdrop of vulnerability and uncertainty surrounding its impacts calls for comprehensive planning and policy responses. The next five chapters describe how adaptation decision making can be made more effective when the following five key elements, tailored to a changing climate are embraced: public engagement, decision-relevant information, institutional design, tools for planning and policymaking, and resources.

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DETLEF SPRINZ: "Only very wealthy and far-sighted societies will be able to afford and actually implement a fully anticipatory long-term climate strategy. . . . Robust adaptive decision-making can help focus on the likely short-term decisions that ought to be taken in order to arrive at desirable long-term future outcomes. Taking short-term decisions that leave the options for benign long-term outcomes open and create political, economic, and social constituencies . . . will enhance our chances to reach that goal."

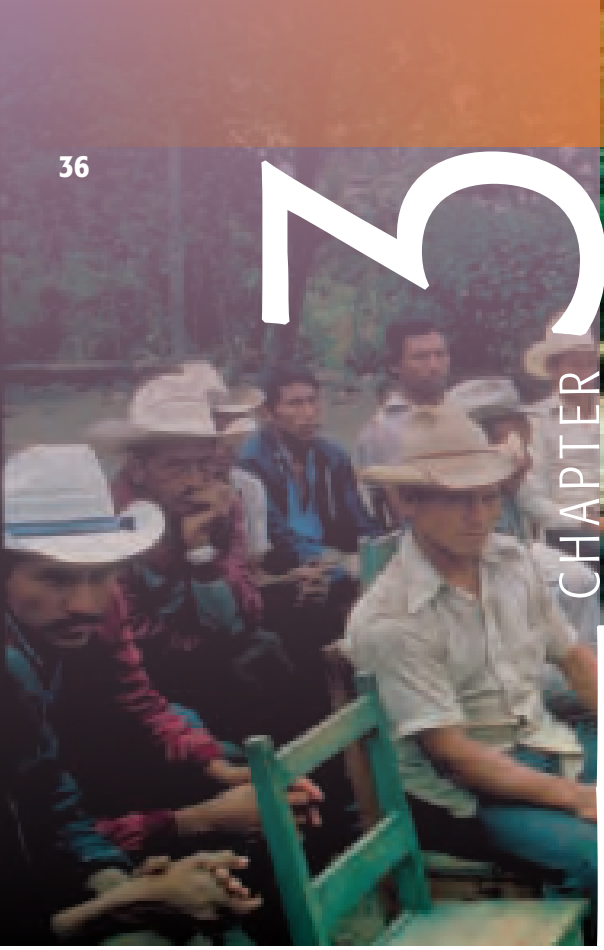
— Detlef Sprinz, Potsdam Institute for Climate Impact Research

WRR EXPERT PAPER

CAROLINA ZAMBRANO-BARRAGÁN: "In order to face decision-making challenges in a context of limited resources, governments can follow a strategy used by businesses in times of uncertainty: reserving the right to play in the future by establishing policies and measures that can help keep options open. This can help minimize social, political and ecological trade-offs and avoid committing to a dramatic strategy prematurely."

— Carolina Zambrano-Barragán, Climate Change Adviser, Quito, Ecuador

CHAPTER 3



PUBLIC ENGAGEME

PUBLIC ENGAGEMENT WILL BE ESSENTIAL TO LAYING THE GROUNDWORK for societies to make the difficult choices that climate change will require. Which climate risks should be addressed, and should they take precedence over other pressing national priorities? Which vulnerable populations, sectors, and ecosystems should be prioritized for adaptation efforts? Questions such as these, and the decisions that flow from them, need to be the subject of debate and, ideally, consensus.

In this chapter, we explore the critical importance of public engagement in decision making in a changing climate, and we try to provide decision makers with specific approaches to promote broad public engagement in adaptation decision making. Such comprehensive engagement will be necessary not only for directly addressing climate risks through the planning and policymaking processes but also for decisions that can affect vulnerability.

IMPORTANCE OF PUBLIC ENGAGEMENT IN A CHANGING CLIMATE

Communities may be the best judge of how climate and weather patterns are changing at a local level. Thus, public engagement in designing adaptation plans and policies is critically important. As we describe in this chapter, and as the excerpts and case studies underline, policymakers can ensure more effective adaptation decisions by engaging those affected by climate impacts and the actions taken to address them.

In reality, however, public engagement in adaptation decision making can be an afterthought. Rather than being active partners, affected communities and other stakeholders are generally consulted late in the planning and policymaking processes or are simply informed of decisions already taken.[1] This is due in part to cultural and capacity barriers that inhibit public engagement. In many cases, it also stems from political and legal barriers, as many affected individuals, communities and organizations lack legal rights to consultation and engagement.

Forms of public engagement employed by governments range from the perfunctory, such as information sharing about decisions already made, or superficial consultation, to the comprehensive, such as joint decisions with government and affected communities, or full citizen control of decisions.

Public Engagement: In Brief

Governments have an obligation to those affected to convey the scale and range of the risks and the expected impacts that climate change will bring.

Public engagement in decision-making processes is an asset for governments, not a burden to be avoided. Engagement can help provide information, prioritize needs, and decide which climate-related risks are acceptable while creating support for adaptation activities.

Governments need to ensure that those affected have legal rights to be consulted and engaged in policy and planning processes.

Engaging the public early, and directly, in assessing climate risks and vulnerability and developing responses for their communities can ensure more effective planning and inclusion of vulnerable populations.

Engaging communities and civil society in collecting, using, and disseminating information, such as local rainfall data, can produce valuable knowledge for both short-term needs and longer-term adaptation measures.

Financial and other incentives can play a critical role in persuading the public to take part in adaptation-related monitoring and implementation activities.

Government-led activities may fail, and investments may be lost, if communities are not actively engaged throughout the policy process, including in implementation and monitoring of efforts and evaluation of results.

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NEIL ADGER: "Fair decision-making on adaptation concerns how and by whom decisions on adaptive responses are made, the recognition and participation of individual voices, and ultimately the legitimacy of the decisions. Fairness in access to decision-making pertains to individuals, groups or nations. The issue of precisely where fairness lies is contested by theorists of democratic decision-making—some stress differences among individual citizens that need to be addressed in fair process, while others argue for collective and group representation. Indigenous peoples, for example, are often marginalized within their own countries or recognize themselves as a group united by their culture across more than one neighboring country. Appealing to citizenship may not be relevant for all. Procedural fairness is interpreted through fairness in rules concerning resources to deal with decision-making elements such as voice, recognition and representation."

— Neil Adger, Tyndall Centre for Climate Change Research

Figure 3.1: Entry Points for Public Engagement in a Changing Climate

This report uses the term "public" broadly to include not only affected communities but also civil society organizations, scientific institutions, universities and the private sector, as well as organizations that represent individual citizens or groups of citizens. We look beyond conventional ways of involving citizens in policy processes—such as referenda and public hearings—and highlight effective and innovative means to involve the public in decision making.

The integration of climate risks into decisions is unlikely to succeed without in-depth and sustained public engagement throughout the policy cycle. Figure 3.1 highlights entry points in the adaptation decision-making process where public involvement is critical.

A first step for successful public engagement is the legal empowerment of those affected (see Box 3.1). Given the scale of government intervention and resources that planning for climate change impacts will require, fair processes—achieved through public engagement—will be critically important in strengthening the legitimacy of decision makers and the actions they pursue.[2] Perfunctory approaches to public engagement are unlikely to secure the substantial benefits that more comprehensive efforts can bring (see Box 3.2).

Responding to and preparing for climate risks will often involve trade-offs, creating winners and losers. But engaging the public at the outset can build awareness of the issues involved and the options available. Such openness can also build public trust and government accountability and, in turn, stakeholder support for action. For example, restricting coastal infrastructure in order to conserve mangroves and the role they play in protecting against storm damage may affect local industries and jobs. In such circumstances, ensuring that the public is fully informed and involved can help make difficult choices be viewed as fair outcomes by communities.

A town meeting in the Iquique Province of Chile.

Box 3.1 Legal Empowerment

The recognition of participation rights is becoming increasingly common as governments acknowledge the legal standing of communities and citizens to have a say in the policies and activities that affect them. International treaties such as the Aarhus Convention and a growing number of national laws have codified such rights as access to information, public engagement, and access to justice.[3] Legal mechanisms such as these can help empower communities in the decision-making process and ensure that community input is integrated into all steps of a planning process.

Simply codifying public engagement into law is not sufficient, however, due to the complexity of many engagement and legal processes as well as the high transaction and opportunity costs that come with being involved with such processes.[4] The WRI publication *A Seat at the Table* identifies eight policy responses to support more inclusive access rights[5] as well as four steps to institutionalize more inclusive access: (1) create access rights; (2) ensure equal application of access rights; (3) ensure equal ability to use access rights; and (4) create additional rights that ensure the ability of the poor to use access rights.[6] Although these steps will look different in each country due to differing contexts and circumstances, examples of each can be found in works such as *A Seat at the Table*[7] and the report "Making the Law Work for Everyone" from the UNDP Commission on Legal Empowerment of the Poor.[8] National governments should design laws that take these steps and strengthen the rights of their citizens to both create more robust outcomes and empower the most vulnerable.

PUBLIC ENGAGEMENT FOR EFFECTIVE DECISION MAKING

In this section we identify specific entry points in the planning and policymaking processes in which public engagement can be a critical element for anticipating and responding to climate change. While public engagement alone does not ensure effective decision making, it is necessary.

Key to all of these steps is a public with full and complete information about climate change, including potential climate change impacts that may affect their communities and the consequences of those impacts. It is a fundamental part of any public engagement process to provide that information so that public engagement is meaningful and relevant (see also Chapter 4).

Problem Identification

Before planning and policy options are even considered, officials should engage the public in defining needs that policies must address to be effective. Such early efforts to engage affected communities, civil society and experts can usefully center on the collection of relevant data. Communities can be engaged by meteorological and other government agencies in vulnerability mapping, collecting seasonal data, developing projections of future change, and monitoring change over time. Public engagement in assessments of risk and vulnerability can in turn galvanize action to improve the communities' preparedness. In Bangladesh, government-led community risk assessments were completed in 32 of 64 districts with the engagement of communities and nongovernmental organizations, resulting in the development of risk reduction measures in every district. Community members first completed a Community Risk Assessment, which combines scientific data and local knowledge to identify, analyze, and evaluate a community's risks and vulnerabilities. They then developed a Risk Reduction Action Plan that listed priority activities, such as training in disaster preparedness, afforestation initiatives, health and sanitary initiatives, and raising the elevation of roads.

Civil society organizations can also help with these assessments, providing a key link between the public and decision makers. When such approaches are not taken, the needs of the most vulnerable are often neglected. For example, Nella Canales, a member of the Adaptation Technical Group of Peru's National Climate Change Commission, reported on how the Central Bank Reserve

Box 3.2 Barriers to and Principles of Effective Public Engagement

Research has demonstrated that public engagement in decision-making processes can lead to better outcomes for those affected by the decisions.[9] Yet, many decisions continue to be made without full public participation.[10] Why is this the case?

There are many barriers to public engagement. Some people cannot participate in decision-making processes because they lack access to communication channels. Others don't have the resources required, such as transportation to public hearings. And some face literacy hurdles, lack official documentation, or do not have rights to participate.[11] Some are even exposed to personal risk if they participate.

Because of power dynamics, some groups, such as women, may not feel they can take part. And those likely to be most vulnerable to climate change may need special help in accessing decision-making processes, as these processes may not be user-friendly for many vulnerable groups. In addition, public engagement processes require significant attention, and can involve trade-offs in time and resources that might deter governments.[12]

A comprehensive study by the U.S. National Academy of Sciences concluded that effective public engagement should be guided by the following principles: "a clarity of purpose, commitment to use the process to inform actions, adequate funding and staff, appropriate timing in relation to decisions, a focus on implementation, and a commitment to self-assessment and learning from experience."[13] If these principles are not embraced, public engagement processes can actually result in worse outcomes than the use of less inclusive approaches by solidifying differences among stakeholders.[14]

Box 3.3 Using Games to Convey Risk in Africa

"The Early Warning, Early Action" card game was designed to facilitate dialogue between forecasters, Red Cross personnel and vulnerable communities. When played in a fishing village in Senegal it led to a new early warning system. The game 'Weather or Not,' playable in an auditorium setting, confronts teams of participants with probabilistic forecasts: they must decide whether to reduce risk ahead of the event or wait and see—and all participants can see how different teams perform.

The IFAD-WFP Weather Risk Management Facility supported the design of a game involving index-based microinsurance bundled with credit for agricultural inputs. Ethiopian and Malawian farmers (many illiterate and even innumerate) played using coupons, a die and real money—allowing participants to gain first-hand experience of the consequences of a range of plausible decisions."

—Pablo Suarez, Red Cross, WRR Expert Paper

of Peru commissioned a study of activities at risk from climate impacts. In the absence of effective engagement processes, the study identified only those sectors with a significant export market, such as agriculture and fishing. Left aside were "thousands of small producers in the Peruvian highlands, whose links with foreign markets are minimal, and who make no significant contributions to GDP."[15] Civil society organizations, she argued, can provide a "voice to these groups ensuring acknowledgement of their high vulnerability in public policy, through policy advocacy."[16]

Analysis of Options

Research for *World Resources 2010–2011* explored several innovative means of engaging the public early in analyzing options to address climate risks, including scenario exercises and games. Simulation exercises conducted in Ghana and Vietnam (see Chapter 6 on tools for planning and policymaking) brought government officials together with civil society representatives and other stakeholders to talk through acceptable levels of risk and policy objectives for their countries' electricity and agricultural sectors. Role playing facilitated dialogue as participants were encouraged to shift from official positions, explore a range of solutions, and seek consensus.

Games can also help the public understand their options and needs in a changing climate.[17] The Red Cross, for example, has employed them effectively as a decision-making tool with African communities (see Box 3.3). According to Pablo Suarez of the Red Cross, standard educational approaches such as slideshow presentations and disaster simulations have been largely unsuccessful at conveying the probabilities associated with an extreme event. These approaches can, however, be usefully complemented by games used in training workshops for both public and civil society engagement in analyzing options for addressing risk.

Prioritization and Decision

For resource-constrained developing countries already struggling to meet their basic needs, taking measures to address climate risks will inevitably require setting priorities. Action will need to be targeted at vulnerable populations, ecosystems and sectors.

Collective agreement among affected groups on acceptable levels of risk is a prerequisite for prioritizing actions.[18] For example, in our Ghana simulation exercise (see p. 98), decision makers decided to proceed with the building of a dam despite the potential higher costs of electricity in the future. For governments, engaging the public in this critically important step can lead to more durable responses to difficult adaptation choices. Because so many actors will have a variety of interests in adaptation activities, trade-offs will be inevitable. Even so-called "low regrets" policies

Participants in the WRR simulation exercise in Vietnam weigh their options.

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FRANCES SEYMOUR: "Making trade-offs between current and future welfare, allocating costs and benefits across stakeholder groups, and taking decisions about what risks to take and how to manage them are all inherently political decisions. Thus one of the most important 'no regrets' investments that all governments must make is in informing their citizens of the adaptation and mitigation choices ahead, and putting into place the democratic processes necessary to enable their meaningful participation in making those choices wisely."

— Frances Seymour, Director-General, CIFOR

which embrace actions that serve both development and adaptation goals involve judgment calls on where to focus investments (see Box 3.4).

In negotiating such tricky terrain, well-established participatory approaches can help government ministries and agencies pursue fair and effective processes.[20] The process of engagement can also help create public and civil society support for tough decisions and may serve as a conflict management mechanism in certain situations. In some cases, dispute resolution mechanisms will be required. For example, owners of beach hotels may want a seawall to protect their buildings from erosion, while the neighboring fishing village does not want them because the natural erosion and accretion helps increase the size of habitats where fish breed.

Of necessity, the level of public engagement in the prioritization step of the decision-making cycle may vary depending on the climate impact. For example, in the aftermath of an extreme event, relief efforts may not have the luxury of time or resources to fully engage those living in the disaster zone in deciding priorities. In such circumstances, other pressing needs will prevail over the ability of stricken communities to participate in decision-making processes.[21] However, shortcuts taken during immediate relief may have to be addressed during longer-term recovery efforts if they are to be durable.

Some governments have already realized and embraced the importance of public engagement in prioritizing adaptation activities. For example, while developing its National Adaptation Programme of Action (NAPA), Sudan undertook a two-part prioritization process. The first step involved convening stakeholders in five different ecological zones, where each group developed both quantitative and consultative criteria for evaluating various adaptation projects. This produced 32 projects with those within each zone ranked in order of importance to the assembled stakeholders. The second step took place at a national level. Specialists, practitioners, and NGO representatives endorsed the priorities suggested by the regional groups while also offering strategic advice on implementation. Groups represented during the prioritization process included farmers, government officials, academic researchers, and NGOs.

Box 3.4 Community Participation and Building Capacity

Even when governments and the private sector do engage affected communities, the latter may not possess the knowledge or skills necessary to fully participate in the decision-making process, especially in the case of "hard" infrastructure projects with many technical aspects. This lack of technical capacity may prevent community members from making informed decisions.

To ensure that affected communities are fully informed about the consequences of projects, plans and policies, governments should work to build capacity among community members to understand the possible outcomes. For instance, in a pipeline project in Azerbaijan, the company building the pipeline hired local partners to facilitate training for NGO groups performing monitoring activities, while also allowing access to the construction site, project documents, and key personnel.[19]

Implementation

Public engagement in implementation of adaptation efforts brings many benefits. It not only taps the expertise and knowledge of local communities and provides more capacity to deploy interventions, but it also lends legitimacy to the actions taken. In turn, the durability of the integration of climate risks into plans and policies can be strengthened.

Over the past few decades, decentralized implementation efforts have aided many policy reforms, facilitating government efforts to be more flexible and responsive to local communities' needs.[22] In addition, participatory approaches can be cost-effective, as local communities are trained to maintain activities. For example, the Chinese government, with support from the World Bank, established farmers' organizations and water users' associations to adopt more efficient irrigation techniques and practices, in combination with new crop varieties. Funded through government subsidies, the farmers' organizations offered training for adaptation activities in the agriculture sector. Oversight of irrigation facilities was also transferred to the water users' associations for maintenance and operation. These efforts to engage the local communities were seen as a key factor in the project's success.

Communities are also more likely to help implement adaptation efforts—for example, by collecting relevant information—if they understand the value of participating and if the opportunities to take part in the decision-making processes address their needs. In Mali, government-led activities to integrate climate risks into the agriculture sector included working with farmers to develop climatological profiles for their individual fields, not just the surrounding agricultural land. After the initial analysis, farmers received 10-day bulletins on hydrological, meteorological, agricultural, and pest conditions, with more specific, downscaled data delivered every one to three days. This "farmer-centered approach" earned the support of rural communities, since they could apply the information they gathered to crop production activities, and there was a clear pay-off. The farmers who used the agrometeorological information earned a significantly higher income from their yields than did those who used traditional indicators.[23]

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MOLLY HELLMUTH: **"In 2010, when the earthquake hit Haiti, the Haitian government was effectively paralyzed. UN organizations stepped in to fill this void, essentially taking charge of emergency response activities. As the rainy season approached, there was concern that the situation could be exacerbated as many people living in tents would now be exposed to flooding, disease (such as cholera) and potential landslides. Yet bypassing existing national government risk structure—which seemed to be a necessity in the days after the earthquake—had the unfortunate side effect of further marginalizing the ability of the Haitian government to take the lead. In the months after the initial shock, UNDP and WMO redoubled efforts to build the capacity of the national meteorological department and the ministry of agriculture to provide climate services and manage climate risks."**

— Molly Hellmuth, International Research Institute for Climate and Society

WRR EXPERT PAPER

ROGER STREET: "The requirement is more than consultations and providing opportunities for feedback. These are part of what is required, but by themselves will have limited benefit if the goal is provision of decision-relevant information . . . particularly . . . when the supply and demands for that information are rapidly changing or suddenly change (new projections) and when we need to learn by doing."

— Roger Street,
UK Climate Impacts Programme

Partnerships with communities, civil society, and other stakeholders can play an important role in implementation as well. For example, in Central Kalimantan, Indonesia, the provincial government adopted an innovative tool for predicting destructive peatland fires in partnership with NGOs and technical experts at a local university. While such uncontrolled fires pose a serious risk to public health and livelihoods and contribute significantly to climate change, they were traditionally regarded as a necessary risk by poor local farmers who use fire to clear land. However, the involvement of CARE Indonesia, a development NGO trusted by the area's indigenous community, helped win over skeptical farmers. The government held workshops with farm leaders explaining how an early warning system would allow them to better manage the use of fires and would help prevent the damage and economic loss from accidental and naturally occurring fires.[24]

Monitoring and Evaluation

Public engagement during monitoring and evaluation of adaptation efforts can assist in understanding how risks on the ground are changing and how effective a given activity is in responding.[25] Incentives and resources can provide "carrots" for participation, as well as offset costs of engaging the public in monitoring and evaluation. For example, in Mali, members of the public taking part in government-led efforts to record and transmit rainfall data have been given bicycles to make their collection of the data easier.

The Radio and Internet for the Communication of Hydro-Meteorological Information (RANET) project in Zambia used similar incentives, giving mobile phones to rural partners who collect rainfall data and periodically recharging them for free. The Zambian Meteorological Department provides seasonal rainfall forecasts and schedules community review meetings for those who participate in collecting this information. As a result, 3,050 community members in remote areas are now taking measurements with rain gauges. In addition, FM broadcasting stations have been equipped with solar and wind-up radio receivers.[26] The private sector is also beginning to play a role in financing such incentives. For example, the international Green Power for Mobiles program provides renewable sources of energy to charge mobile phones in areas off the electricity grid.[27]

Conversely, adaptation efforts may fail if those affected are not engaged in monitoring, operations and oversight. This was a key lesson that emerged from efforts in Nepal to prevent deadly glacial lake outburst floods (GLOFs) triggered when the water dammed by a glacier or a moraine is released. (See Nepal case study, p. 46.) GLOFs have the potential for causing significant destruction in downstream valleys. The Tsho Rolpa glacial lake is the largest in the Nepali Himalayas; a decade ago, the threat of it flooding downstream valleys led the Government of Nepal to take proactive measures. These included lowering the lake's level by three meters and setting up an emergency warning system. While these measures were thought to be necessary to avert a catastrophic flood, public buy-in was limited. When initial interaction between government officials and the community lapsed, there was little follow up. While mountain village residents helped construct the early warning system—keeping the operation and maintenance expenses low—the early warning devices eventually were pillaged and made unworkable.[28] The Nepalese case demonstrates that public engagement in the initial implementation is not enough. Ongoing public engagement and community self-interest are needed to maintain effective adaptation activities.

For public engagement to be effective, both the decision makers and the public need information about current and future risks posed by climate change as well as the vulnerability of those affected. The next chapter describes the importance of various types of information in the context of climate change and highlights innovative technologies and other means to collect and distribute information effectively.

VIETNAM: Restoring Mangroves, Protecting Coastlines

LOCATED IN THE TROPICAL MONSOON BELT, VIETNAM IS EXTREMELY VULNERABLE TO IMPACTS FROM climate change, particularly to increases in the intensity of coastal storms and a rise in sea level. Large-scale mangrove restoration and rehabilitation is considered a key adaptation intervention in Vietnam, with very different results in the North and the South. This case study examines Vietnam's efforts to use mangroves as an adaptation intervention and illustrates why governance has been crucial to its success.

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Reports validated by Vietnam's government show that the country's average annual temperature has risen by 0.5 to 0.7 degrees Celsius in the last 50 years.[1] Over the same period, sea levels around its coastline have risen 20 centimeters. These climatic changes have taken place in the context of a greater than 80 percent loss of mangrove forests since the 1950s, caused by defoliation and more recent coastal development, which in turn has magnified the impact of storm surges on coastal areas.[2]

As a result of current and projected future climatic changes, Vietnam's agricultural and water resources sectors, including its all-important rice crop, are becoming more vulnerable to both the intrusion of saline water and floods. Storm surges can also severely damage coastal infrastructure and the dikes and structures that protect the rapidly developing aquaculture industry. Climate change scenarios for the Mekong delta suggest that by 2050, 45 percent of the total land area (or 1.77 million hectares) will be salinized.[3] Research suggests that a rise in sea level of one meter would have a serious impact on 11 percent of the population and cut Vietnam's gross domestic product by ten percent.[4]

The national policy for climate change adaptation in Vietnam is a combination of hard and soft measures. In response to and along with some other Asian countries, Vietnam initiated large-scale mangrove restoration and rehabilitation programs with the support of such donors as the World Bank and international-aid NGOs like the Red Cross. Since 2001, the restoration and rehabilitation of mangroves have reversed the trend of deforestation, adding a net 15,000 hectares of new forest, for a total coverage of 155,290 hectares in 2008. In addition, the Ministry of Agriculture and Rural Development announced a plan to invest 20 trillion

Making adaptation part of a comprehensive development planning process has benefited stakeholders.

Vietnamese dong (VND) to upgrade the country's coastal dike system, with mangroves acting as a protective mechanism for the constructed dikes. Mangrove forests will also be included as part of the national plan for Integrated Coastal Management developed by the Ministry of Natural Resources and Environment.

THE REGIONAL DIFFERENCE:
Mangrove Plantations as a Hard and a Soft Adaptation Measure

In the North, the government has promoted mangrove plantations to protect sea dikes, which serve as a "hard" risk mitigation measure to protect coastal settlements from storms. Most mangroves have thus been given protective status, thereby denying local inhabitants' user rights. This in turn has led to conflicts of interest with the lucrative shrimp aquaculture industry and the mangrove plantations over claims to coastal wetlands. In addition, marginalized members of society have been displaced, particularly women dependent on access to the coast to harvest non-cultivated seafood like clams and crabs.

The North's largest mangrove restoration and rehabilitation program was run by the International Red Cross and funded by Japan and Denmark. It sponsored local governments' mangrove restoration and rehabilitation projects, which employ villagers to plant and protect the mangroves. These projects, in eight provinces, have resulted in the planting of 18,000 hectares of mangroves along a 100-kilometer stretch of sea dike to provide a protective barrier for the infrastructure.

The protective function of mangroves in Kien Thuy District (Thai Binh Province) was demonstrated during the tropical cyclone Damrey in 2005. Here, the coastline's restored mangrove system lowered the wave height from an estimated 4 meters to 0.5 meters, and the dike emerged unscathed. But since 2006, when the Red Cross's support ended, the compensation for local people for protecting the mangroves has dropped significantly, so much so that it no longer provides the incentive needed for their continued help.

Most of the mangrove plantations in the North are monocultures that maximize the trees' protective attributes, a forestry management approach that the local people oppose as not providing productive habitats for wild fisheries, clams, and crabs.[5]

Experience from a mangrove restoration research site in Tien Hai District (Thai Binh Province) established by the European Union in the Red River delta shows that engaging the help of the community is becoming difficult. Some villagers complain that the program does not adequately compensate them for reducing their access to crabs and clams, which has subsequently led to a rise in the illegal cutting of mangroves.[6]

In the South, donors and local governments have taken a very different approach. They have treated the restoration and rehabilitation of mangroves as a "soft" multifunctional effort to alleviate poverty and diversify livelihoods as well as to protect coastlines. Many plantations are both rich in species and managed under several land use arrangements allowed by the law, so that in most areas individuals are given ownership of the land.

Accordingly, mangroves have provided fishing communities with both ecological goods and services and livelihood benefits. This is especially the case in areas where restoration has been coupled with capacity building and training as well as the provision of social services like schools and health clinics, and infrastructure like roads and electricity.

According to government statistics, since 2000, 77 percent of mangrove forestland in Vietnam's southern provinces has been designated as "productive"[7] and allocated and leased to 33,000 households and 62 collective groups/organizations. A typical example is the Coastal Wetlands Protection and Development Project implemented in the Mekong Delta between 1997 and 2007. This project combined mangrove plantations with issuing leases to forestland to nearly 8,000 households.[8]

LESSONS LEARNED

Vietnam's experience with mangrove restoration in different regions of the country suggests that adaptation approaches with a single objective, such as protecting coastal infrastructure from a rise in sea level, can lead to unanticipated conflicts and consequences that hinder achievement of the ultimate goal. Residents of local communities have been denied the ability to earn a livelihood from the mangrove forests and wetlands because of their "protected" status, yet there is no "market" to compensate them. Part of this failure lies with the conventional planning approach offering only the limited involvement and participation of multiple stakeholders, especially local communities.

In contrast, the South has been more successful to date, making adaptation part of its comprehensive development-planning process, in that it has provided benefits to all stakeholders. Moreover, restoring mangroves within a broader action-planning process is a "low-regret" approach and thus is more likely than a single-objective alternative to secure more benefits for communities and industries, despite future uncertainties.

ENDNOTES

1 Tai et al. 2009.
2 Tai et al. 2009.
3 CCFSC 2001.
4 Dasgupta et al. 2007.
5 Osbeck et al. 2010.
6 Osbeck et al. 2010.
7 Que 2003.
8 World Bank 2008a.

CASE STUDY

NEPAL: Containing Glacial Lake Outburst Flood Risks

GLACIERS HOLD ABOUT 70 PERCENT OF THE WORLD'S FRESHWATER, AND ARE PARTICULARLY susceptible to changing temperatures. With melting glaciers an early and already apparent climate change impact, mountainous countries are seeking effective ways to adapt.

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In Nepal, glaciers cover about 9.6 percent of the country's total land area[1] and, owing to warmer temperatures, are measurably shrinking, forming glacial lakes that can burst and cause destructive glacial lake outburst floods (known as GLOFs) in downstream valleys. Average temperatures in Nepal are rising by an estimated 0.04 to 0.09 degrees Celsius each year, with greater warming at higher altitudes,[2] thereby increasing the threat of GLOF incidents.

In the late 1990s, the government of Nepal took measures to prevent the bursting of Tsho Rolpa glacial lake, the largest of its kind in the country, located about 110 kilometers northeast of the capital city, Kathmandu. Some experts believe that these measures averted a disastrous flood and thus offer useful lessons for future interventions.[4]

RISK PREVENTION MEASURES

In 1997, following warnings from scientists that the lake presented a serious risk of flooding, the government of Nepal commenced both short-term and long-term measures to prevent this and to reduce the damage it could cause. To alert downstream communities of an outburst flood event, a warning system based on VHF (very high frequency) radio technology was put in place to relay alarms from the Tsho Rolpa sensors to warning stations installed along the local valleys. The warning was issued by air horns backed up by electronic sirens.[5] Data management centers, manned by expert personnel, were set up to monitor the system's performance. Finally, a Meteor Burst master station using the ionized trails of meteors to extend the range of transmitted radio signals to more than one thousand miles was constructed to transmit and receive signals from the warning stations and a sensing station.[6]

Nepal's proactive effort at GLOF prevention contains both positive and negative lessons for its government and those of other mountain nations.

With support from the Dutch government, physical structures were installed to reduce the size of the lake. These included test siphons to lower the lake level without pumping and, later, a gated open channel to enable a controlled release of water. In 2000 the construction of the open channel was completed and subsequently lowered the lake level by three meters.[7] In addition, to warn inhabitants of downstream settlements and authorities of a flood event, an automated GLOF sensor system was installed, with support from the World Bank. The sensors were located just below Tsho Rolpa to detect changes in outflow, and a redundancy component was included to avoid false alarms.

LESSONS LEARNED

Nepal's proactive effort at GLOF prevention contains both positive and negative lessons for its government and those of other mountain nations.

Collaboration with donor agencies was critical to the rapid deployment of measures once the threat from Tsho Rolpa was identified; equally important was the coordinated effort of a range of government departments. The installation of test siphons at the lake and of the manual early warning system, administered by the Nepalese army, was a coordinated effort led by the Department of Hydrology and Meteorology, with support from the Nepalese army, Nepalese police, Ministry of Home Affairs, and Department of Water Supply. By engaging scientists in the policy process, the government also ensured that the project would be implemented on a sound scientific and technical basis.[8]

Community engagement also was effective during the implementation phase, with local people employed to build the physical structures to lower the lake level as well as to build the early warning systems.[9] For a long time, because the VHF radio at the lake site had been the villagers' only means of communication, the early warning systems were a key factor in helping establish the project's importance to the community.[10]

Although the lake's overflow channel is still functional and well maintained today, by 2002 the Tsho Rolpa early warning systems had been destroyed and thus had ceased operation. This failure can be attributed to an absence of maintenance funding, as well as the loss of awareness and concern by local communities, which seem to have forgotten about the threat of a glacial lake outburst.[27] Inadequate ongoing public education about the risks of floods and the lack of engagement with local villagers through training programs in the use and importance of the early warning system may explain the loss of public support and the destruction of the system.

CHARACTERISTICS OF GLACIAL LAKE OUTBURST FLOOD IMPACT RISKS

Uncertainty: A glacial lake outburst flood can be triggered by various elements such as rock/ice avalanche, earthquake, ice calving. Scientists can identify the presence of such elements but not predict exactly when an avalanche or earthquake will occur.

Changes in mean climate system: The formation and growth of glacial lakes in Nepal, including Tsho Rolpa, can be attributed to climate change. Studies suggest a significant warming trend over Nepal and that the warming rates increase progressively with elevation.

Time lag and sudden change: Glacial lake outburst floods build up slowly over time and can occur unexpectedly, causing the need for both long-term preventative measures and fast-reacting response mechanisms.

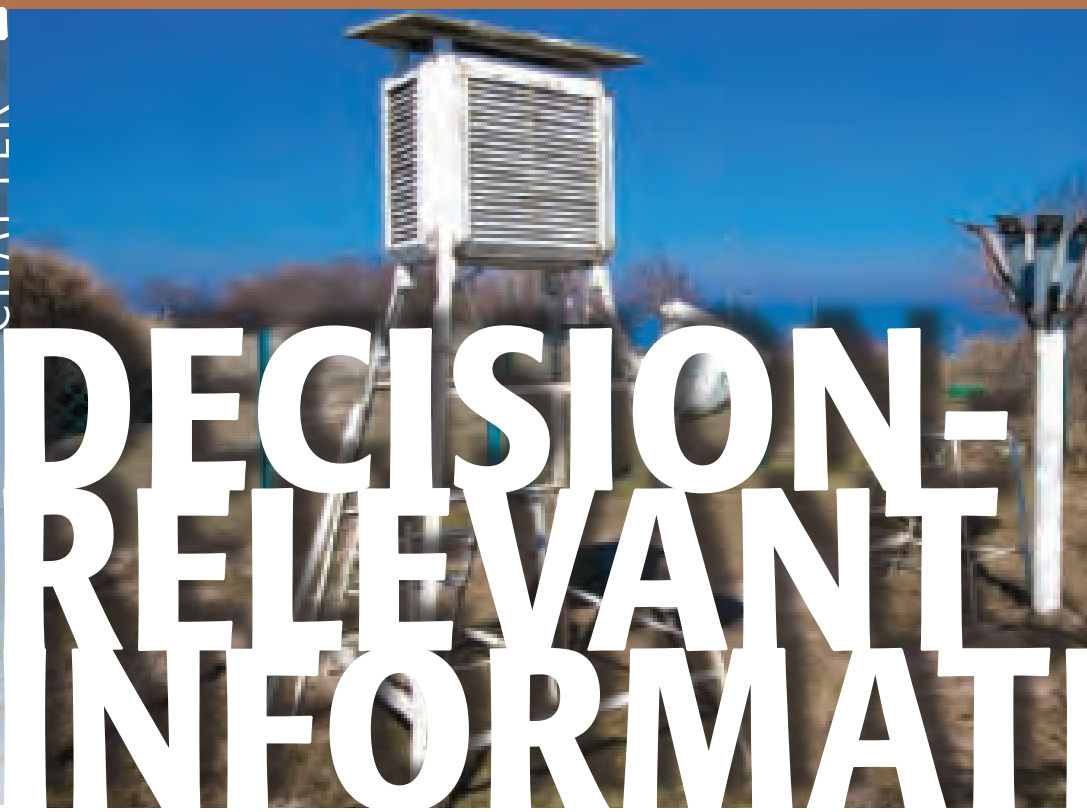
Spatial dimensions (widespread impacts): The spatial dimension of the glacial lake outburst flood impact can be very variable and depend on the size of the lake, characteristics of the release of the water, and geomorphologic configuration of the valley downstream. A glacial lake outburst flood includes water flowing at a very high velocity and mixed with large amounts of debris. Damage within the impact area can be extensive. Indirect impact due to loss of transportation means, hydropower generation, and other services can be on a national scale.

ENDNOTES

1 ICIMOD/UNEP 2001; Sharma 2010.
2 Shrestha et al. 1999; Xu et al. 2007.
3 Dahal 2008; Rana et al. 2000; Shrestha et al. 2004.
4 Meteorcomm LLC 2010.
5 Bell et al. 1999; Meteorcomm LLC 2010.
6 Dahal 2008.
7 Department of Hydrology and Meteorology 1997.
8 Shrestha 2010.
9 Shrestha 2007.
10 Dahal 2008.

CHAPTER 4

DECISION-RELEVANT INFORMATION



THIS CHAPTER SEEKS TO HELP NATIONAL-LEVEL PUBLIC OFFICIALS identify first, the types of information useful for making effective plans and policies in a changing climate; and, second, the means to collect and distribute such information to those who need it most. It also explores information capacity-building needs in developing countries and the application of technologies for information collection and dissemination.

For climate change adaptation, decision-relevant information is not just—or even primarily—about climate information such as meteorological data. As we discuss below, non-climate information can be just as important.

Information will need to be collected and disseminated by different groups across society. The people who need specific information to make effective adaptation decisions include not only national governments, but many other interests and sectors. They include, for example: water managers facing uncertain rainfall trends; small-scale farmers seeking information about crop-affecting changes in seasonal weather patterns; health officials alert to the spread of disease; and inhabitants of drought-prone regions threatened by water shortages. Enabling countries to adapt to climate change will therefore require establishing systems that transfer relevant information from the national to the local level and, vice versa, as well as horizontally across ministries and communities.

The "what" (what types of information are needed) and the "how" (how is that information collected and disseminated) aspects of adaptation information are closely linked. Raw data are of little use if they cannot be made understandable to target audiences and distributed to them in a timely fashion (see Box 4.1). Likewise, distribution mechanisms such as early warning systems for floods or hurricanes are useful only if accurate and timely data are being fed into them.

IMPORTANCE OF INFORMATION IN A CHANGING CLIMATE

Planners and policymakers contending with a changing climate need information about the relevant risks, the vulnerability of exposed populations, the available adaptation options given the resource constraints, and the effectiveness of those options on the ground. As a general guide, our

TION

Information Needs: In Brief

Governments seeking to use information effectively for decision making in a changing climate, and donors and researchers seeking to support them, need to focus on what types of information are required, by whom, and how this information is collected and disseminated in a usable form to those who need it.

Information for adaptation planning and policymaking goes far beyond climate information; demographic, economic, social, and environmental information is also vital if actions are to meet the needs of those affected.

Information needs to be user-driven, sufficient, accurate, accessible, long-term, frequently updated, cost-effective, and targeted.

Many developing countries lack the basic infrastructure and capacity to gather and distribute information necessary for decision making in a changing climate.

Investments in weather-monitoring stations and other data collection systems are of great value for collecting information about changes on the ground and for providing the raw data for forecasts. They are much needed in many parts of the world, especially Africa and South America.

Given that information needs and information itself will change over time, systems for collection and dissemination will need to be both durable and updated seasonally and annually.

Dissemination strategies must at times be rapid, especially for extreme events, and able to reach remote communities and inform government strategies.

Information must be decision-relevant and accessible to the public if it is to be a foundation for inclusive, effective, adaptation decision making.

Innovative information and communication technologies exist that hold promise for supplying information needed to protect vulnerable lives, livelihoods, and ecosystems.

Box 4.1 Data versus Information

In this report, we make the following distinction between data and information:

- Data consist of isolated objective facts or observations that may not be useful without further analysis or translation.[1] In regard to climate, such data could be a region's temperature records over a specific period.
- Information is data that have been organized, shaped, or presented in a way that is meaningful and useful to its end user. For example, a farmer may not need a spreadsheet of his region's rainfall data over the past 40 years, but if these data indicate what time of year he can generally expect to receive the maximum rainfall, they become meaningful and useful information. The farmer can then add this information to his existing knowledge about what crops to plant under certain conditions and when to plant them.

As scientific agencies continue to collect and disseminate more and more data,[2] decision makers and scientists must be aware of, and act on, the need to translate this into usable information. Although the specifics of this process will differ based on the type of information needed, decision makers should set up participatory forums for end users to indicate what sorts of information they need in their particular circumstances.[3]

Box 4.2 Weather Monitoring Stations in Africa

Weather monitoring stations collect data on precipitation, temperature, humidity, wind speed and direction, and soil moisture.[4] In 2003, there were 1,152 functioning World Weather Watch[5] stations in Africa: only one station per 26,000 square kilometers, which is eight times fewer than the World Meteorological Organization's minimum recommended number.[6] Large parts of Central Africa remain uncovered, and many stations that do exist function only intermittently.[7]

research indicates that effective information for decision making in a changing climate has the following characteristics. It is:

- User-driven, taking into account intercultural considerations, and therefore of practical application to communities, civil society, the private sector, and other stakeholders.
- Sufficient in scope and scale to draw effective conclusions for plans and policies and to make clear the uncertainties, limits, and available opportunities.
- Accurate enough to support risk and vulnerability assessments and help define what levels of risk can be accommodated.
- Accessible to those who need it to adjust their actions or behavior.
- Supported over the long term and frequently updated, since many climate impacts will take place over decades.
- Cost-effective, given that limited resources are available to support information management systems.
- Targeted to specific risks, vulnerable populations, and ecosystems, in order to avoid information overload.

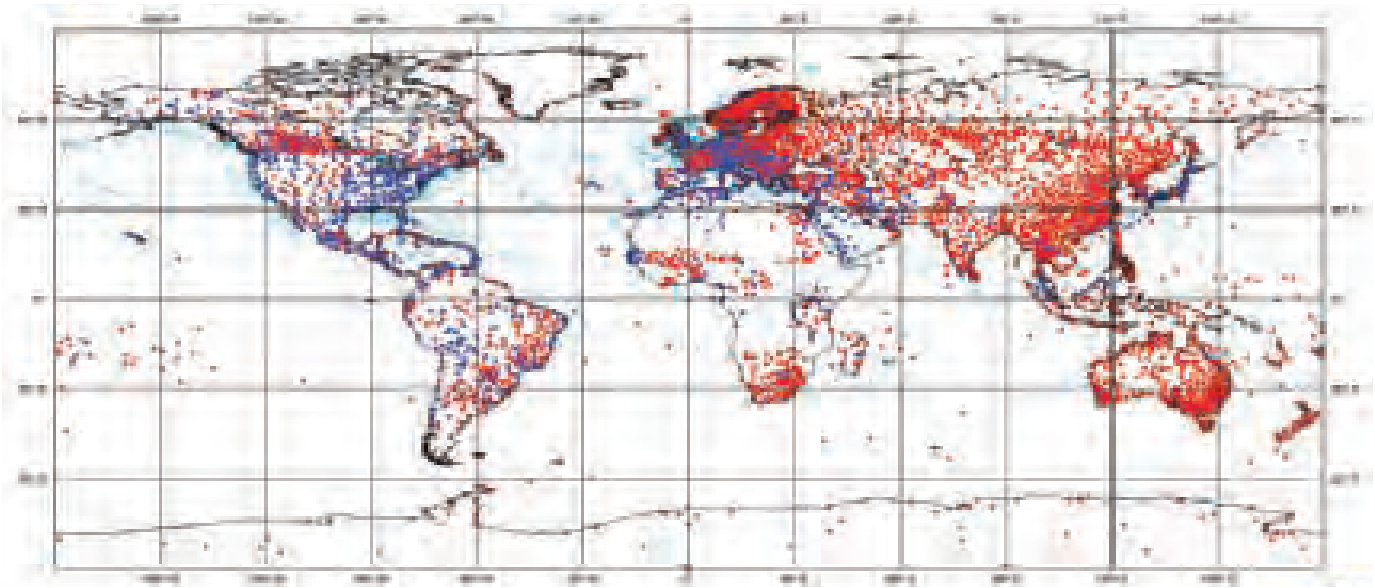
Many decision makers trying to respond to or prepare for climate risks lack decision-relevant information that meets all, some, or even any of these conditions. Often, this is because governments do not ask potential users to specify the information they need. But these potential users may not always know what information they need or even that they need any. As discussed in Chapter 3, an important element of effective decision making is an engaged public informed about climate change and its potential consequences.

In addition, there is a lack of investment in climate-monitoring infrastructure, such as weather stations and water gauges (see Box 4.2). As a result, these gaps in critical information may hinder some countries' and communities' ability to assess risks and vulnerability and achieve adaptation objectives. Governments and donors should not, therefore, underestimate the importance of filling these gaps.

For example, African nations have, on average, eight times fewer land-based weather stations than the minimum number recommended by the World Meteorological Organization.[8] Andean countries like Peru, Bolivia, and Ecuador, which are already experiencing the consequences of retreating glaciers, face similar obstacles. Not only are data recorded at widely spaced regional meteorological stations, but they often cannot be extrapolated to the local level, owing to these countries' wide range of altitudes, microclimates, and ecosystems. In the province of San Ignacio, Peru, for example, one lone meteorological station operates in an area of 5,000 square kilometers with elevations ranging from 460 to 3,800 meters above sea level.[9]

To address such gaps, governments are collaborating through the World Meteorological Organization to develop a Global Framework for Climate Services, whose goal is to improve information services for all countries, enhance data exchange, and build capacity.

Figure 4.1 Map of Weather Data Reporting Stations: European Centre for Medium Range Weather Forecasts



Source: ECMWF

INFORMATION FOR EFFECTIVE DECISION MAKING

Effective adaptation means identifying and satisfying information needs. Merely having the "right" information in place, however, does not ensure that a policy or plan will adequately address the risks or opportunities presented by a changing climate.[10] For successful implementation, information also must be collected and disseminated in ways that serve those who need it.

Next we identify the types of information required for the different needs that climate change will impose on decision makers and then give examples of effective collection and dissemination mechanisms we found in our research.

INFORMATION FOR IDENTIFYING WHERE TO PRIORITIZE ACTION

Non-Climate-Related Information

Even though climate change is a global phenomenon, its effects will be felt locally. In responding to or anticipating change, national decision makers will need information to know where within their borders to target and prioritize action. Governments will need to know which populations, sectors, and ecosystems are most at risk in order to assess the consequences of climate impacts and decide where best to focus their action. When collecting information on non-climate drivers of vulnerability for a particular area, decision makers might consider the following categories:[11]

- Social and economic systems: poverty, livelihoods, social capital, gender, health, age, education, and the ability to transport goods and services.
- Institutions: interpersonal and inter-ministerial power structures and relationships, regulations, roles and responsibilities, and capabilities.
- Range and type of stakeholders affected.
- Local physical infrastructure: roads, bridges, and power stations.
- Ecosystem conditions: the health of forests, soil quality, wetlands, and water basins.

It is important to concentrate on trends—not just data snapshots in time—and to understand the interactions between the climate and the non-climate drivers of vulnerability. Although collecting these data sounds difficult, some of this information may already be available but stored

A student at the International Maize and Wheat Improvement Center in Mexico conducts an experiment.

in disparate central or local government locations. It also may exist outside government structures, such as in the form of indigenous knowledge.

Equally important to note is that locally specific factors,[12] which may vary from one district to the next, also have a large bearing on vulnerability, both between and within communities. Investing in research and the engagement of communities can help public officials uncover the underlying causes of vulnerability and target adaptation efforts to them. Although collecting such social, economic, institutional, stakeholder, infrastructure, and environmental data and translating them into useful information can be resource intensive, the investment may help in other areas of policymaking, such as development planning, poverty reduction, and management of natural resources.

Moreover, the communities themselves have some awareness of what factors make them vulnerable. Often they have long-standing indigenous knowledge of how to respond to change.[13] Although climate impacts may change and intensify as the average global temperature continues to climb, such traditional knowledge is still useful as a starting point for decision makers.

Climate-Related Information

Non-climate information about vulnerability will need to be combined with information about relevant climate risks in order to assess and compare the needs of different areas and to decide on priorities for action. Many existing climate risk assessment methodologies can help decision makers prioritize their adaptation actions (see Chapter 6).[14]

Diana Liverman, a leading climate adaptation expert at the University of Oxford and the University of Arizona, suggests that governments adopt the following approach to gathering climate data: "The basic tool kit should include information on current climate, observed changes underway, and projections of future climate based on alternative trajectories of greenhouse gas emissions—usually a business as usual scenario and others that assume some efforts to reduce emissions."[15] This translates into three types of information to enable governments to target adaptation actions to specific types of climate change: *historical* information, *real-time* information, and *forecasts*.[16]

Historical information provides baseline risk data to track trends and is often used in forecasts.[17] For example, the International Maize and Wheat Improvement Center (CIMMYT) in Mexico has established 123 research stations to collect data on crop growth under various conditions. In partnership with scientist David Lobell at Stanford University, they used this historical information to correlate yields with past temperature records. This exercise revealed that for every day of the growing

season that temperatures exceed 30 degrees Celsius, yields diminished by at least 1 percent per year, rising to 1.7 percent per year under drought conditions.[18] By revealing the vulnerability of crop species, this information can aid adaptation strategies in the agricultural sector.

Real-time observations monitor changes on the ground over time and are critical to responding to extreme events and heightened variability. In the next section, we discuss strategies for collecting such data.

Forecasts of weather and climate conditions and changes can help governments, climate-sensitive sectors, and communities plan for the future. Those forecasts that focus on daily and seasonal time frames are good starting points[19] for decision making in sectors such as agriculture. The accuracy of such forecasts is limited, however, given the uncertainties involved, especially for longer forecasts. In Mali, for example, many farmers are now trained to use agrometeorological information (whereas in the past, they used traditional indicators of change, such as the appearance of birds or changes in vegetation).[20] The country's meteorological agency supplies the farmers with rain gauges, calendars for planting, and daily and three-day weather forecasts. The African Centre of Meteorological Application for Development also provides the government with seasonal forecasts to inform localized food security measures. In the 2003/2004 season, farmers who used the agrometeorological information had greater yields and a higher gross income for all the crops they grew (Mali case study, p. 64).[21]

Although many developing countries lack the technical capacity and resources to perform modeling, partnerships can strengthen such skills. For example, the Comprehensive Disaster Management Programme initiated in Bangladesh over the past decade led to the establishment, at the Bangladesh University of Engineering and Technology, of a "climate change study cell" that focuses on regional climate modeling and impact assessment.[22] This study cell partnered with the United Kingdom's Hadley Centre, a world-class climate-modeling organization that is part of the Met Office, to receive training on a regional climate-modeling system. As a result of this partnership, 20 professionals from both government and nongovernmental organizations in Bangladesh now have the expertise to create their own projections of climate impacts.[23]

Long-term projections may have improved as a result of enhanced understanding of the Earth's climate system, technological advances, and extensive data gathering,[24] but many data gaps still exist. In particular, more decision-relevant data on future temperature increases, sea level rise, precipitation changes, and their impacts on ecosystems, hydrological cycles, and physical systems, such as ice coverage in regions like the Himalayas and the Andes, are needed. Also, while models tend to agree on the global scale of changes, local projections are less certain and therefore of less clear value as a basis for action.[25] Many decisions also are based on historical data relationships such as past precipitation and run-off trends, precedents that will not always be an accurate guide for long-term planning (see the quotation from Yolanda Kakabadse).[26]

In light of these various uncertainties, it is not always necessary or helpful for governments to make exhaustive efforts to improve climate model projections. Indeed, this can be a resource-intensive, technically challenging, and expensive exercise, and in some cases, detailed climate projections are not required to make adaptation decisions. Instead, such projections are typically most relevant to decisions that are expensive, strategic, or high stake, require long-lived investments (for example, public infrastructure, such as major dams), are particularly sensitive, or require long lead times.[27]

INFORMATION FOR DEFINING ACCEPTABLE LEVELS OF RISK

Given the multitude of pressing needs facing governments, the resources and capacity available for adaptation efforts will stretch only so far, even with outside assistance. Public officials, along with those affected, will need to decide which climate-related risks are acceptable and which must be managed. Such choices are subjective[28] and may be contentious. Some communities, for example, may consider unacceptable the inundation of a coastal area by rising seas and to be avoided by all possible means, however costly, while others may concede its inevitability. There can be no universally agreed-on "acceptable" level of risk because the various stakeholders will have different values, preferences, and consequences.[29]

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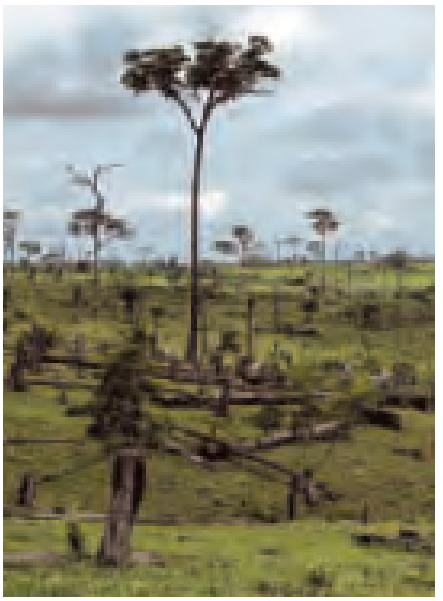
YOLANDA KAKABADSE: "When engineers design water infrastructure, they look at the history of a particular basin to estimate the 'normal' range of water quality, quantity, and timing. The basic assumption has been that the past is an effective means of understanding and preparing for the future. However, as the earth's climate has accelerated its rate of change in recent decades, this fundamental assumption has become increasingly unrealistic. . . . In the Himalayan foothills, for instance, climate and flow data from recent decades may not be capturing new trends in the variability of the Indian monsoon and shifts in seasonally frozen water and snow. . . . Impacts from changes in freshwater availability can already be heard from subsistence farmers who report shifting from four to two reliable harvests per year. New small and medium hydropower facilities in the Himalayas are 'locked in' to estimated flow regimes that are already out of date at the time of completion, resulting in investment losses, inefficient energy production, and significant risks to downstream populations."

— Yolanda Kakabadse, WWF International



Deforestation in Capixaba, Acre, Brazil.

As we point out in Chapter 3, the public's engagement in deciding what types and levels of risk those affected are willing to absorb is critical to ensuring fair processes and lending legitimacy to government actions. Inherent in these difficult choices is the need to weigh different interests and values, especially those of the most vulnerable segments of society. Effective choices cannot be made in a vacuum by government decision makers; they also need the public's engagement.

Several steps can be taken to gather information for determining acceptable climate-related risks. Public officials should lead a process on agreeing on the objectives and planning and policy options (including taking no action). These options should then be considered in light of such criteria as effectiveness, costs, and benefits, and the possible consequences of each option should be identified. Finally, officials and stakeholders should select which climate risks they will address.[30] This process should not be a one-time step but should be iterative and responsive to ongoing information updates, altered perceptions of risk, and changes on the ground (see also Chapter 3).[31]

INFORMATION FOR CHOOSING ADAPTATION OPTIONS

After identifying target areas for action and acceptable levels of risks, the next step for decision makers is to choose their options. This will require additional information on the effectiveness, costs and benefits, and consequences of each course of action, as well as public attitudes toward and constraints facing their implementation. Much of this information and engagement will be part of deciding on the acceptable risks. In addition, in order not to waste scarce financial and other resources, decision makers should determine whether the measures are flexible enough to withstand changing climatic conditions and whether they should be implemented in advance or be adopted quickly when needed.[32] For example, flexible and robust decision route maps, described in Chapter 6, can aid planners in such diagnoses.[33]

INFORMATION FOR IDENTIFYING THRESHOLDS

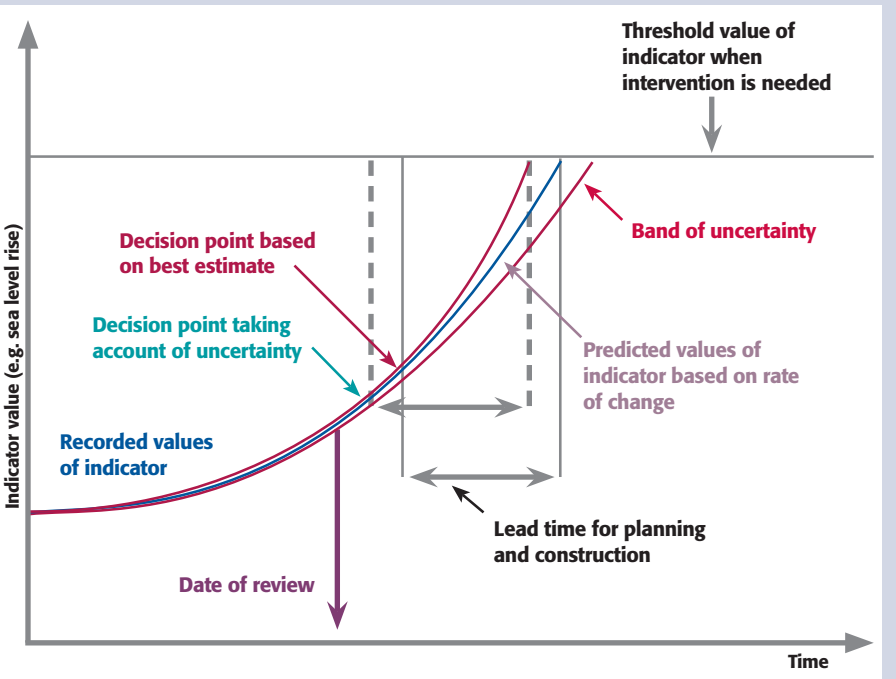
To enable effective decision making, information-gathering processes for adaptation must also identify (as far as possible) the presence of thresholds in natural, social, and human-built systems. A threshold is the point at which either an abrupt change or a series of small changes can result in

Box 4.3 Relevance of Thresholds to Decision Making: The Thames 2100 Experience

In the Thames 2100 project, decision makers have embraced a flexible approach for managing uncertainty so that the Thames barrier, a protective structure for the city of London, can withstand multiple levels of sea level rise. To this end, they have deployed the following decision support tool:

For each adaptation option, the project assessed: the key threshold of climate change at which that option would be required (e.g. the extreme water level); the lead time needed to implement that option; and therefore, the estimated decision-point to trigger that implementation (in terms of an indicator value, such as the observed extreme water level, with an uncertainty range).

— Tim Reeder, UK Environment Agency, and Nicola Ranger, Grantham Research Institute on Climate Change and the Environment, UK. WRR Expert Paper



large-scale, persistent, and potentially irreversible shifts, such as the collapse of a major bridge, the disappearance of glaciers, or the transformation of rainforest into savanna.[34] Knowing where these changes will take place can help generate activities on which lives, livelihoods, public services, and the future of ecosystems may depend.

Engineers know where the critical thresholds are for many human-built systems, such as public infrastructure. For example, they may know under what conditions a water main will no longer operate effectively. Once such thresholds are identified, information-based action can be taken to avoid overshooting them. Accordingly, if a bridge will not withstand more than 1.3 meters of rising water levels, changes in sea level rise can be monitored and more aggressive action can be taken if the bridge's limit is threatened (see Box 4.3).

Many thresholds, however, are not well understood. This is especially true of ecosystems,[35] which provide vital services such as freshwater and food and which face threats from land use conversion, pollution, and other factors, as well as climate change. For example, the Brazilian Amazon provides critical water and climate regulation services on which the region's agricultural sector depends. Yet recent scientific studies suggest that ongoing deforestation combined with climate change could bring the Brazilian Amazon to a tipping point beyond which it experiences widespread forest dieback and transitions into savanna-like vegetation in some places.[36]

Some of the highest priority adaptation efforts should be understanding, slowing, or preventing the crossing of thresholds. Not only will losses of entire ecosystems be devastating to those who depend on them, but they also may have unknown consequences beyond their borders. Indicators for monitoring long-term change can help decision makers determine when systems vital to human well-being are nearing a tipping point. Below we describe such indicators, among other strategies for collecting and disseminating information.

We have discussed the various categories of information for effective adaptation decisions in detail, and it is important to point out that these are not independent of one another. Information needed to assess adaptation options overlaps with information collected to determine what risks may be accommodated. That information may also be part of the data collected to determine vulnerability. As climate risks become integrated into national-level planning and as governments coordinate those efforts across sectors and governance levels, the value and relevance of these types of information will increase.

COLLECTING AND DISSEMINATING INFORMATION FOR EFFECTIVE DECISIONS

As climate change intensifies, collecting and disseminating decision-relevant information will become more urgent and will need to expand in both scope and scale. Both the greater variability that will result from a changing climate and the long-term nature of many climate-related impacts mean that information for adaptation must be regularly updated over long periods of time. Some types of information that have not been collected in the past also may be needed for adaptation efforts. Collecting and distributing adaptation-relevant information at the scale and over the long periods of time required[38] is a huge task that will require greater financial investment and a significant upgrading of human capacity by governments and donors (see Box 4.4). Expert groups will need access to databases, methodologies, and plans, and those affected will need understandable and relevant data.

Both long-term political will and community buy-in will be needed as well to provide the capacity and support for expanded collection activities. Climate-related surprises are likely to trigger the need for rapid information collection in affected areas after a disaster has occurred (e.g. see Brazil case study, p. 81), and vulnerable countries will need to strengthen their capacity accordingly.

Once collected, information needs to be analyzed and distributed quickly to those who need it in a user-friendly and timely manner. For example, early warning systems must be able to reach areas vulnerable to extreme events in enough time for people and livestock to reach shelter before the cyclone or floods strike. Adding to the challenge facing governments, information for climate adaptation must reach all those who need it. A central online clearinghouse of data may not be

Box 4.4 Donor Support for Weather-Monitoring Stations

Funding basic monitoring services does not always lead to immediate or obvious results, but having a baseline of historical data with as few gaps as possible is crucial for developing countries as they work to develop plans and policies for adapting to climate change. Donors and governments should evaluate the value of such information and prioritize the funding of these stations so that policymakers can accurately track changes as they make decisions for the future.

Donors should realize, however, that while they can support countries in improving their information-gathering infrastructure, if such support is not long lasting, with a clear and appropriate exit strategy to ensure local ownership, it can actually harm these capabilities. In Kenya, donor-funded projects that sought to rehabilitate weather-monitoring stations and build new ones led to a drop in overall monitoring capacity when donors ended their support; Joe Kibiiy, with the Department of Civil and Structural Engineering at Moi University in Kenya, describes the situation:

"Ironically, donor funding towards the expansion of the hydromet network has led to worsening rather than improving the situation. . . . In all instances, the management of the networks deteriorated as soon as the donor pulled out because the meagre financial allocations by the government were now directed to a vastly expanded network... Many of the stations are inoperational at any given time. As a result it is difficult to get any full set of data."[37]

A farmer in Mali.

accessible to a rural community in developing countries. Conversely, members of that community may be able to receive cell phone text messages or radio.

Likewise, information is not valuable if it is not usable. Technical assessments should be explained in layperson's terms, and communications should be translated into local languages and made easy to interpret for use on the ground. For example, agrometeorological information provided to farmers in Mali to help them maximize their yields amid changing climatic patterns is translated not only into the national language but also the numerous local languages[39] (see Mali case study p. 64).

Another example of user-friendly climate information comes from Indonesia, where a predictive tool for peatland fires used to inform the management of controlled burns was accompanied by a step-by-step guide for local farmers and public officials, workshops with hands-on simulations, and an online platform. The training workshops were simultaneously translated into a variety of languages spoken in Central Kalimantan, which led to greater understanding and acceptance by local communities and a greater ability for the meteorological agency, communities and other project partners to exchange information.[40] The training workshops also were made publicly accessible online (see Indonesia case study p. 67).

Engaging local populations in collecting comprehensive information is essential in order to inform, implement, and monitor adaptation policies and initiatives. Incentives for collecting local information—and distributing it to the government and to other communities—may often be necessary to ensure its ongoing provision (see Chapter 3).

Promising innovations as well as effective traditional means are at the disposal of governments and donors seeking to harness information to adaptation needs. Although information will need to be gathered at all levels and flow between national and local levels and vice versa, central governments will play an important role in such activities. Figure 4.2 summarizes a potential flow of information for adaptation and gives examples of promising collection and dissemination strategies.

Collection

Although common forms of information collection, such as observation, questionnaires, surveys, and interviews, still are useful for gathering climate and socioeconomic data, a changing climate will also necessitate the use of other methods and practices. The following are some promising approaches for use in the developing world and are based on the expert and practitioner research commissioned for this report.

WEATHER-MONITORING STATIONS

Weather stations are critical to collecting data, yet many vulnerable countries have few or none at all. Coverage can be challenging for both financial and logistical reasons.[41] Baseline data, often used in forecasts for both national and local activities, such as adjustments in crop planting, are typically collected from weather station networks. The data gathered include precipitation, temperature, humidity, wind speed and direction, and soil moisture.[42] These data can be augmented by satellite observations, when available, that provide indications of storms and non-climate drivers of change, such as rates of deforestation relevant to adaptation planning.[43]

COLLABORATIVE NETWORKS

Collaborative platforms, engaging multiple partners and/or jurisdictions, especially at the regional level, can assist in gathering data and making them relevant to decision makers. One such platform is the Group on Earth Observation (GEO), which is made up of 86 nations and supports access to data generated by measurement, remote sensing, and predictive modeling.[44] As an example of impact on the ground, GEO provided information to decision makers in the aftermath of Haiti's earthquake regarding where to rebuild in order to minimize the vulnerability of settlements to future seismic events.[45]

VISUAL MONITORING

Visual monitoring is a low-cost method that does not depend on advanced technology and can be used to track local climate-related trends over a given time. In Namibia, local-level visual monitoring has been used in farming regions (see Namibia case study p. 61). For example, in one community, agricultural extension workers asked farmers to describe the health of their livestock by matching the condition of their animals to pictures that conveyed health status ranging from "very poor" to "very good." The condition of local fodder availability was determined by taking pictures at sites and providing these images to national agencies. This form of collection involves the community in a way that requires a minimum amount of training or specialized knowledge.[46]

VOLUNTARY GEOGRAPHIC INFORMATION

Voluntary Geographic Information (VGI) relies on community members to submit data to a central source by using such technology as mobile phones and computers. These data can be used to "fill in the blank spaces on the map," providing more concrete information, such as the location of roads and buildings, in areas where it previously did not exist.[47] An example is the Google Map Maker project, which allows users to update maps in more than 180 countries and regions. Edits are then reviewed by other users to ensure their accuracy.[48]

VGI has also proved useful in responding to disasters. In the aftermath of the 2010 earthquakes in Haiti, for example, VGI was used in relief efforts by enabling survivors to share information about which roads were impassible and where survivors might be located, resulting in a better targeted response.[49] Although promising, VGI relies heavily on users' access to technology like mobile phones and computers, which can be prohibitively expensive or rendered useless in an infrastructure loss during a disaster.

Figure 4.2 Collection and Dissemination of Information

Examples of Information Collection Strategies (local, regional and national sources)	Examples of Information Dissemination Strategies
• Data from weather stations	• Video
• Regional centers for information collection	• Radio
• Indicators for monitoring long-term change	• Mobile phones
• Visual monitoring	• Communication satellites
	• Early warning systems

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MOLLY HELLMUTH: "Of course, real societal benefits from… information can only be realized if the information is actionable, that is, only if there exists in parallel the infrastructure, communication technology, active institutional relationships and policies and the capacity to produce, interpret and act on the information at scale."

— Molly Hellmuth, International Research Institute for Climate and Society

Box 4.5 Information Needs for Different Users

Different groups need different kinds of information and at different times. As the Mali case study demonstrates (see p. 64), a continuous flow of basic weather data, coupled with short- and long-term forecasts, can help farmers make more confident planting and harvest plans.

Ireland's government recognizes that many adaptation decisions will be carried out at the local and regional levels, which requires providing information to those governments as well as to certain sectors and populations. Accordingly, the government established the Irish Climate Information Platform (ICIP), which allows the Irish Environmental Protection Agency to set priorities for what information will be provided, when, and for what audiences. When fully implemented, the program is designed to be the central source for all relevant information, to be accessible to a variety of end users, and to act as the principal data resource for local, regional, and sectoral decision making.[52]

INDICATORS FOR MONITORING LONG-TERM CHANGE

Indicator data for monitoring long-term change are particularly useful for avoiding tipping points that may harm adaptation activities and investments. When thresholds are known, such indicators can help decision makers decide when to take more aggressive action. When interventions are undertaken without knowledge of relevant thresholds, indicators can still play a critical role in monitoring signs of stress. For example, vegetation die-off or other symptoms of stress should be recorded, as they might be early signals of tipping points.[50] This data collection effort may, however, compete with short-term needs in affected communities, and the support of nongovernmental organizations and donor agencies may be needed.

Dissemination

Effective methods of information distribution will be crucial in a changing climate, and modern communications technology is paving the way. Approaches like those described next not only enable national and local government initiatives but also encourage communities to pursue adaptation efforts.

A wide range of dissemination methods are already in use; examples are word-of-mouth communication, television broadcasts, Internet databases, email and text alerts, and social media platforms. Below we highlight some additional promising approaches, which have widespread application potential for adaptation purposes. While we focus on formats for communication, channels for information are important as well. Trusted organizations, such as churches or NGOs, can act as centers for passing on information. In Namibia's efforts to monitor local agricultural indicators, the national government worked with a preexisting farmers' association, already trusted by the local population, to implement local monitoring[51] (see Namibia case study p. 61).

VIDEO

Participatory video methods that highlight the promise and pitfalls of risk reduction activities are being tested by NGOs and some government agencies. In one successful effort, the Malawi Red Cross Society and Malawi Meteorological Services experimented with videos in which subsistence farmers already using adaptation strategies described them for the benefit of neighboring villages. The strategies emphasized were diversifying crops, using whistles to warn of floods, and raising ducks (because they can float, ducks are less vulnerable to floods than other animals). When floods struck the area in 2009, one village that had watched the video moved their harvest to higher elevations while other surrounding communities lost part of their harvest and needed food aid.[53]

RADIO

Radio is a good way to communicate information and has long been used in development initiatives. Now it is increasingly being embraced in adaptation-targeted efforts. For example, the Zambia Meteorological Department's RANET (Radio and Internet for the Communication of Hydro-Meteorological Information for Rural Development) project is using community radio (as well as mobile phone and satellite technologies) to bring locally specific weather and climate information to remote areas.[54] The project translates all weather information transmitted over the radio into local languages and can be used to broadcast seasonal climate information as well as warnings about extreme weather, such as storms that could threaten the safety of livestock.[55] In a similar initiative in Mali, ten-day bulletins with planting information have been transmitted by radio and television to rural regions of the country. Despite poor reception in some rural areas, these bulletins have helped low-income smallholder farmers to decide when and what to plant, thus increasing their yields.[56]

MOBILE PHONES

More than three-quarters of the world's population is served by mobile networks, and additional efforts are being made to reach those who do not yet have access. Mobile phones can be powerful tools for quickly transmitting information. For example, the RANET project is collecting and disseminating climate and weather information via SMS texting.[57]

COMMUNICATION SATELLITES

Satellite communication devices can also be useful for rapid communication. The RANET project, funded by several international agencies, is piloting an innovative satellite-based communication system, the "Chatty Beetle," in Zambia and other countries. This uses communication satellite technology to send short (160 or fewer characters) messages communicating climate information and weather warnings to remote communities. The "Beetle" is a small terminal that emits a visual and audible signal when a message is received and also supports two-way messaging.[58] According to Riedner Mumbi, the RANET Zambia project coordinator, it transmits information faster than the Internet.[59]

EARLY WARNING SYSTEMS

The dissemination of information about imminent extreme events can be crucial in limiting the loss of lives, livelihoods, infrastructure and assets, and the degradation of ecosystems.[60] For example, the use of a nationwide early warning system in Bangladesh for Cyclone Sidr led to the evacuation of three million people, thus limiting the storm's death toll to 3,500 people.[61] Though devastating, this was far fewer than the 138,000 deaths resulting from a similar storm a year later in Myanmar, where no warning was given.[62]

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CRISTINA BUETI & DAVID FAULKNER:

"76 percent of the world's 6.8 billion people are now served by mobile networks. Further investment and technical ingenuity are needed to serve the remaining 24%, who may live in sparsely populated areas with no access to grid electricity and/or have low incomes.

An example of how information and communication technologies can help in reaching people in remote areas is the 'Green Power for Mobiles' initiative, which is pioneering alternative power sources such as solar and wind for mobile base stations to serve the billion people without access to grid electricity."

— Cristina Bueti, International Telecommunications Union
— David Faulkner, Climate Associates

Employing an early warning system involves several steps: risk assessment, hazard monitoring and warning, dissemination and communication of information, and enabling response.[63] The first three steps all require information. For example, the first step in establishing a famine early warning system may be collecting information about crop varieties, nutrition, markets, and migration to assess vulnerability in an effort to foresee losses and prioritize relief.[64]

Research suggests that early warning systems can be most effective when decentralized and incorporated into existing community practices. Such an approach can be targeted to users' needs and knowledge,[65] with the information provided in a form matching users' needs[66] and in local languages and numbers understandable to the illiterate. At the same time, because warnings of certain extreme events originate from national government agencies, national and local systems must be able to work together in order to be of value to those at risk. For example, a radio attached to an early warning system for glacial lake outburst floods in Nepal was for years the only means of outside communication for the threatened local community, which resulted in a close relationship between the villagers and the decision makers.[67] Although the system ultimately failed because those affected were not involved in ongoing monitoring and the equipment was destroyed (see Chapter 3), this example highlights the kinds of co-benefits that early warning systems can have for poor, vulnerable, and remote communities.

Channeling information efficiently and swiftly from national to local government to communities, and vice versa, requires considerable organization and coordination, as well as leadership and tailored mandates. National institutions are vital not only to overseeing such efforts but also to many other aspects of planning and policymaking. The next chapter explores the design of effective institutions for a changing climate.

NAMIBIA: Local Forums Help Combat Land Degradation

OFTEN DESCRIBED AS "THE LAND BETWEEN TWO DESERTS," NAMIBIA IS THE MOST ARID COUNTRY South of the Sahel. Indeed, the driest parts of the country receive an average of only 20 millimeters of rainfall a year, and research on the vulnerability of the country's agriculture to climate change predicts even less rainfall in the future, coupled with more intense individual rainstorms.[1]

Susan Tambi Matambo, Independent Consultant

Mary Seely, Desert Research Foundation of Namibia

In order to prevent more land from becoming barren and the desert from encroaching, over the past 15 years Namibia's government has pursued pioneering bottom-up approaches to natural resources management, particularly within the agricultural sector. These include the establishment of local Forums for Integrated Resource Management (FIRMs), which, since 1996, have enabled farmers and extension service providers to exchange locally relevant information that in turn informs decision making for sustainable crop and livestock management.

Begun in the northwest of the country and now adopted in rural communities nationwide, the FIRM approach was established to counter Namibia's long-standing climate variability and extremes and not as a response to climate change. Nevertheless, the potential of this approach to enhance communities' capacity to withstand shocks and land degradation will be important as variability is heightened in a changing climate, and it could offer a model for replication both within and beyond Namibia.

The program is focused on Namibia's communal areas, where rural communities have only basic land rights. According to World Bank figures, 63 percent of Namibia's population live in rural communal areas, and the majority of these people are economically disadvantaged.[2] Livestock farming is the main livelihood in these areas,[3] and its success depends on using the commons as the key resource for maintaining the animals. Thus, cooperative decision making is vital to the local communities' well-being.

Central to the success of the FIRM approach is a complementary decision support tool known as "local level monitoring," in which farmers identify and monitor critical indicators over a given timescale. These usually include rainfall (measured by a volumetric rain

This approach has succeeded by giving ownership to the local people who depend on the land.

POTENTIAL IMPACTS OF CLIMATE CHANGE IN NAMIBIA

Uncertainty is an issue already affecting the rangelands and livestock industry. Communities' livelihoods are affected by variable rainfall, in turn resulting in variable rangeland conditions that cannot be relied on from year to year or even from decade to decade.

Changes in mean climate, such as changes in temperature and precipitation levels, will affect the environment supporting the livestock industry and may cause a shift northward to more suitable rangeland (Dirkx 2008).

Change in the climate system's variability in the form of an increase in already high precipitation is expected to influence rangelands' productivity.

The widespread geographic scope of climate change impacts is expected to influence the entire country, making suitable grazing refuges difficult for herders to find.

Climatic extremes are expected to extend their range and become more acute.

gauge), fodder condition and availability, and livestock condition. Farmers measure the condition of their livestock by matching 25 of their animals each month with five pictures of livestock ranging from very poor to very good health.

Additional information concerning the marketing of livestock, animal health and nutrition, rotational grazing, and other rangeland management practices is provided through the forum by representatives of agriculture, veterinary, and water management government agencies.

FIRM meetings are held either monthly or quarterly in villages. Community organizations share the results of local monitoring, and government representatives share information about new government policies and programs and identify additional information needs in the community. Joint courses of action also may emerge from these meetings, such as the adoption of communal herding to address a shortage of land for grazing. In such cases, the local community makes the final decisions regarding sustainable natural resource management.

Examples of improvements in livestock and crop management made by FIRM farmers are selling livestock at the beginning of dry periods and banking the income, actively herding their animals toward healthier rangelands, and jointly buying livestock medications. Farming communities have also acted collectively to establish rotational grazing and to rest grazing lands in danger of degradation. Some of the more evolved FIRMS, known as "innovation platforms," have improved community access to markets and to better technologies for livestock management.

LESSONS LEARNED

The forums have largely been successful, not only in building institutional capacity and social capital at the local level, but also in nurturing rural communities' feeling of inclusiveness and trust in the central government. The approach has succeeded by giving ownership to the local people, who depend on the land, and encouraging local solutions to land management issues.

While the initiative has greatly improved communication between government officials and local farmers, it has not yet had a significant impact on national laws. Funding also is an issue, as most of the forums are supported by donors, making them unsustainable when the donors' financing dries up. In addition, the effectiveness of some FIRMs has also been undermined by a lack of continuity among staff and in the support of initiatives from various stakeholders.

The following table summarizes the key achievements and challenges of this approach:

Taking a FIRM Approach: Achievements and Challenges

ACHIEVEMENTS

- Involves a variety of stakeholders interested in the same issues.
- Serves as a platform for sharing information and knowledge.
- Provides a platform for integrated planning and targets support where needed.
- Puts the community in the "driver's seat."
- Is conducive to improving understanding and developing a long-term vision.
- Minimizes the duplication of activities.
- Provides a holistic picture of the challenges and opportunities for a community.
- Allows opportunities for participatory monitoring, evaluation, and adjustment of planned activities.
- Improves transparency with respect to the partners' roles and responsibilities.
- Ensures the more efficient use of human and financial resources.

CHALLENGES

- Mainly initiated by external service providers.
- Lack of buy-in from some important partners in natural resource management.
- Issues of local power have a negative effect on the community. Lead community-based organizations may sometimes become the "elite" in their community.
- Competition among service providers is sometimes one sided.
- Lack of long-term sustainable funding.
- Some service providers (e.g. extension services and governmental organizations) do not always attend meetings.
- The FIRMs' organizations, including extension service providers, nongovernmental organizations, and community-based organizations, often lack continuity and have a high turnover.

SOURCE: Adapted from Seely and Montgomery 2010.

ENDNOTES

1 Dirkx 2008; Galvin et al. 1996; Hulme 1996.
2 USAID 2010.
3 Mendelsohn 2006.

CASE STUDY

MALI: Helping Farmers Manage Climate Risk

THROUGHOUT THE 1970s AND 1980s, A SERIES OF DROUGHT-RELATED FAMINE EVENTS PLAGUED the Sahelian region, prompting the government of Mali to take action to help farmers respond to local variations in rainfall. This approach has broad relevance today, as developing countries face heightened weather variability and stronger, more frequent extremes as a result of climate change.

Molly Hellmuth, Cathy Vaughan, Rémi Cousin, International Research Institute for Climate and Society (IRI), Earth Institute, Columbia University

Daouda Zan Diarra, Direction Nationale de la Météorologie, Mali

Run by Mali's national meteorological service, the government project supplies farmers with seasonal weather and climate information, via radio and television bulletins, at critical times during the growing season. Launched in 1982, the project was the first in Africa to supply climate information directly to farmers. It also taught farmers how to measure changes in temperature and rainfall and how to use climate-related information in making agricultural decisions.

Today, the program involves government agencies, research institutions, media outlets, extension services, farmers' groups, and more than 2,500 farming families. The project's farmers consistently report higher yields, and correspondingly higher incomes (10 percent to 80 percent increases relative to those not in project areas), than do those producing crops without the benefit of locally tailored weather data.[1] Anecdotal evidence also indicates that the project has empowered the farmers to invest more in new technologies and to seek agricultural information that can help improve their management practices.[2]

FIGHTING FOOD INSECURITY

Mali constantly struggles with food insecurity, with half its 13.1 million people surviving on less than one dollar a day, four out of ten children underweight, and 11 percent of its citizens undernourished.[3] The persistence of Mali's food deficit is linked to the country's low technological capacity and to its heavy reliance on agriculture in the face of an inhospitable climate. Even though less than 4 percent of Mali's land is suitable for cropping, 80 percent of its population depends on agriculture for its livelihood. Even in the country's relatively rainy south, where most of its people live, frequent drought makes predominantly rain-fed agriculture a high-risk venture. As a result, Mali's all-important cereal production (3.8 million metric tons in 2007) is highly dependent on rainfall. Maximizing crop production is therefore a key priority for the country.[4]

The project succeeds by offering climate services that meet farmers' needs.

Mali's agrometeorological project was carried out with technical support from the World Meteorological Organization (WMO) and funded by the Swiss Agency for Development and Cooperation. The project gave farmers gauges to measure rainfall in their fields and trained them in using these measurements to make decisions based on sowing calendars, which indicate suitable planting dates and appropriate crop varieties depending on the rainfall measurements. The farmers also received ten-day bulletins on local hydrological, agricultural, and pest conditions, in addition to daily and three-day weather forecasts.

The table shows the impressive yield and income gains for farmers making crop management decisions in various project areas using agrometeorological information, compared with those making decisions without this benefit.

The effective collection and communication of information are the cornerstones of the project's success.

Before being processed at three different levels, data are collected from such diverse sources as the WMO, the International Research Institute for Climate and Society, the African Centre of Meteorological Application for Development (ACMAD), the national meteorological service, rural development and agricultural extension agents, and farmers. Seasonal forecasts, produced by ACMAD using data from international sources, are processed by a multidisciplinary working group that includes representatives from the meteorological service, the Ministry of Agriculture, agricultural research institutes, rural development agencies, farmers' groups, and the media. These data are used to prepare ten-day forecasts, which provide basic information and advice to farmers, including the state of crops, water resources, and weather conditions. The government also uses the seasonal forecasts for food security planning.

The national meteorological service prepares daily and three-day weather forecasts that are based on WMO standards and targeted to specific areas or regions. These forecasts are then broadcast by national and local radio stations, and farmers use the information to make decisions like when to prepare land, sow, and/or apply fertilizer and pesticides. Climate information is broadcast in both French (the country's official language) and all major local languages.

LESSONS LEARNED

The success of Mali's agrometeorological project can be attributed to several factors, including its community-level focus and the creation of a unique pathway of communication—connecting farmers, agricultural extension workers, the meteorological service, and a multi-sector team of national and regional experts. The project's approach offers climate services that meet the farmers' needs. Indeed, farmers' statements suggest that as a result of the information, they feel less exposed to risk and are thus more confident about purchasing improved seeds, fertilizers, and pesticides.

Finally, long-term support from both the Swiss Agency for Development and Cooperation and the World Meteorological Organization, which provided technical backup, has been critical to the government's ability to begin to incorporate climate risks in its agriculture sector.

The project has also run into challenges, however, particularly the difficulty of providing reliable local forecasts regarding the onset of the rainy season and the timing of possible dry spells for certain locations. More information is needed, too, on local soil conditions and water availability. Finally, the farmers' low literacy rate and difficulties in translating technical terms into local languages have presented problems.

Crop Yields and Farm Incomes in Project Areas, 2003/2004 Season

Development Zone	Field Type*	Area (ha) Yield (kg/ha)	Average Income (US$/ha)	Gross Income Gain in Agromet. Fields (%)
PEARL MILLET				
OHVN	Agromet	2,600	1,204	175	26
	Non-agromet	67,168	957	139	
DRAMR	Agromet	750	757	110	10
	Non-agromet	45,790	690	100	
ORS	Agromet	10,400	1,247	181	48
	Non-agromet	461,915	840	122	
SORGHUM				
OHVN	Agromet	5,375	1,427	193	42
	Non-agromet	470,996	1,005	136	
DRAMR	Agromet	28,275	955	129	10
	Non-agromet	222,662	871	118	
ORS	Agromet	2,850	1,562	212	56
	Non-agromet	179,853	1,002	136	
MAIZE				
OHVN	Agromet	6,075	1,984	249	80
	Non-agromet	27,079	1,105	139	

NOTE: OHVN = Office de la haute vallée du Niger; ORS = Office de riz ségou. DRAMR = Direction régionale d'appui au monde rural;
SOURCE: SDC et al. 2004.
*Agromet=agrometeorological data.

ENDNOTES

1 Hellmuth et al. 2007.
2 Hellmuth et al. 2007.
3 EC-FAO 2010; WRI 2007.
4 Dembélé et al. 2003, WRI Earthtrends 2007.

INDONESIA: Managing Peatland Fire Risk

THE UNCONTROLLED SPREAD OF FIRES IN PEATLANDS POSES A SERIOUS RISK TO PUBLIC HEALTH, livelihoods, and conservation efforts in Indonesia and contributes significantly to emissions of greenhouse gases.

Shiv Someshwar, International Research Institute for Climate and Society (IRI), Earth Institute, Columbia University

Esther Conrad, Department of Environmental Science, Policy and Management at the University of California, Berkeley

Rizaldi Boer, Centre for Climate Risk and Opportunity Management in Southeast Asia and Pacific, Bogor Agricultural University, Indonesia

In 1997/1998, peatland fires across Indonesia blanketed the region in haze, left millions suffering from respiratory problems, and cost billions of dollars in economic losses across Southeast Asia.[1] The fires also contributed the equivalent of 13 to 40 percent of global carbon emissions from fossil fuels in 1997.[2]

Fires have been a traditional means of clearing land. But with the draining of many peat areas for large-scale palm oil operations, combined with extreme dry seasons, fires have burned out of control. This program is designed to give farmers and officials the ability to manage fires so as to avoid using them when conditions could result in uncontrolled spread. Peat fires often burn under the surface of the land and thus are extraordinarily difficult to extinguish once they are out of control. Peat fires also emit large amounts of greenhouse gases.

Since 2006, the International Research Institute for Climate and Society (IRI) at the Earth Institute of Columbia University and Bogor Agricultural University have worked with the Indonesian government and NGO partners to help develop a proactive early warning system for managing fires in Indonesia's peat heartlands of Central Kalimantan Province. The effort involved researching links between climate and fire, developing tools to analyze rainfall patterns and predict the risk and potential severity of fires up to two months in advance; it also involved training district and provincial government officials and NGOs. These tools were created to help local officials charged with suppressing fires to better target their efforts to prevent uncontrolled fires, with the resulting damages and GHG emissions, while at the same time protecting farmers' livelihoods.

TOOLS FOR FORECASTING FIRES

Central Kalimantan Province is home to about 2.2 million people, the majority of whom depend on agriculture and agroforestry for their livelihoods. In recent decades, the peat soils

Strong partnerships and user-friendly training were key to public acceptance.

making up much of Central Kalimantan have dramatically changed as millions of hectares have been converted from forest to farmland and palm oil plantations. These drained peatlands are at higher risk of fire because of lower moisture content, and the risks are especially great when rainfall is below normal.

Indigenous Dayak households use fire seasonally to clear land, as it is the least expensive method and also helps eradicate pests and improve soil fertility.[3] Since the 1990s, oil palm companies have also used fire extensively,[4] despite national legislation prohibiting its use on plantations.

In 2007, the IRI / Bogor University project team explored linkages between seasonal climate patterns and fire activity and then used their findings to develop an online fire early warning tool. (The likelihood of fire is based on the correlation between past rainfall data and other climate observations, such as ocean surface temperatures and current fire activity.) The tool makes predictions based on two key inputs: seasonal forecasts, updated monthly, of the likelihood of higher or lower than average fire activity across the province; and district-level rainfall data updated every week and a half. The latter data are used to match historical records with new patterns of rainfall.

Consultations at community, district, and provincial levels revealed that a one- to two-month early warning of the likely severity of fire would be the most useful way of deploying the tools, which were made available online in both English and Bahasa Indonesia. Because deploying predictive tools was a significant departure from the then

current practice, which focused on short-term fire suppression, provincial and district-level decision makers and technical staff were given intensive training.

As a result, over the past few years, the potential for fire activity has been predicted two months earlier, leading to better management of controlled burning to clear land. The Provincial Environmental Office uses this tool to supplement early warning information and also to coordinate meetings on fire control and management, chaired by the provincial governor.

To complement the forecasting service for farmers, the Indonesian government passed a regulation in 2008 that sets the conditions under which controlled burning is permitted (the use of fires to clear land by large plantation operations is not permitted, but that ban is often violated). This regulation requires local authorities to use the seasonal climate information to assess the fire risk and decide whether or not to allow controlled burning by farmers during the upcoming fire season, thereby superseding a previous regulation banning all use of fire.

While implementing these regulations has been challenging, because farmers have few alternatives to controlled burning, the result has been an improvement over the blanket ban, which had caused much resentment in the communities and was often ignored because of the hardship it caused.

LESSONS LEARNED

Trust and close collaboration with provincial and district agencies, the involvement of local partners, a problem-driven research approach, and substantial efforts to make tools and research results accessible to local stakeholders all helped in the project's success.

Key partners in the effort were CARE International–Indonesia and the Provincial Environmental Office of Central Kalimantan Province. While IRI and Bogor Agricultural University produced credible, high-quality research, it was the relationship that CARE Indonesia had built over several years of on-the-ground development project work on health and natural resources management in the villages of Central Kalimantan that enabled the project to gain wide acceptance.

Also important were efforts to develop user-friendly and accessible training materials so that a wide range of stakeholders, including dispersed indigenous communities, could join in the effort.

The design of appropriate incentive systems for farmers is crucial to the success of regulating fire risk and requires further research on alternatives to using fire, their costs, and institutional mechanisms for offering such incentives and for monitoring fire use. Currently, farmers, particularly those practicing shifting cultivation (moving to different fields during a season), do not have other economically viable options for clearing land besides using fire. To avoid burning, they therefore would need financial or other support from government. The longer lead time offered by the seasonal early warning system could be instrumental in developing an incentive-based fire management program that enables planning and action over a longer time horizon while alternative practices can be explored.

The experience in Central Kalimantan could be extended to other fire-prone provinces in Indonesia, through the development of similar early warning tools tailored to local contexts. The project may also offer insights for decision makers creating adaptation tools and approaches that seek to manage ahead of time those activities contributing to climate change and other risks.

ENDNOTES

1 Page et al. 2002.
2 Casson 1999.
3 Kinseng 2008.
4 Casson 1999.

CHAPTER 5 INSTITUTIONAL DESIGN

IN THIS REPORT, WE FOCUS ON NATIONAL-LEVEL DECISION MAKING FOR a changing climate. However, the efforts of central government institutions charged with adaptation planning and policymaking must also inform, and link closely with, efforts by each country's provincial (or state) and district (or local) authorities to enable tangible, locally appropriate action to address climate risks.

By creating enabling environments for local-level action, national institutions play an important role in shaping outcomes on the ground. Likewise, national governments also have a role to play in regional and international adaptation policymaking and financing, through negotiating and policymaking forums like the UN Framework Convention on Climate Change (UNFCCC).

The risks that climate change poses can undermine the future development of the world's poorer countries. But this urgency is not yet reflected in the institutional arrangements of many developing country governments. In developing countries, in particular, there is a vital need to integrate climate change risks into their economic development and poverty reduction strategies. At present, governments often view preparation for climate change risks and impacts solely as part of environmental policy. Or they address adaptation on an ad hoc, project-level basis with little coordination among ministries.

In this chapter, we focus on the ways that institutions can be designed or modified specifically to support adaptation decision making. To this end, we define institutions quite narrowly and limit our discussion to governmental organizations, such as cross-sectoral and sectoral ministries, legislatures, national cabinets, and local councils.

Government institutions most relevant to climate adaptation include economic development and finance ministries; sectoral ministries such as those responsible for environment, water, energy, agriculture, and transport; and more specialized agencies such as meteorological and disaster relief institutions. Under the best circumstances, national climate change coordination agencies will also play important roles, but to date, few countries have established these.[1]

The ways in which institutions are designed can dictate not only the type of adaptation actions that are adopted but also how effective they are on the ground.[2] As we describe in this chapter, certain institutional arrangements can facilitate the development and deployment of the kinds of responsive, proactive, robust, flexible, and durable plans and policies required for effective decision making in a

Institutional Design: In Brief

National institutional arrangements can be designed to enable local-level adaptation and can make a significant difference in outcomes on the ground.

The choice of government institutions to lead and coordinate national adaptation efforts can dictate outcomes; fostering leadership can have a similar effect.

Institutional mandates, supported by capacities to implement them, can be better designed for climate risks; they can include, for example, long-term planning horizons and mechanisms for rapid response and regular updates.

Coordination among national-level government agencies and with other stakeholders and governments at local, sub-national, regional and international levels greatly strengthens countries' adaptation efforts.

Establishing or strengthening an institution responsible for national emergency and disaster response is an important first step toward incorporating climate risks into the structure of government.

The ideal design of an institution will vary depending on the type of climate change it seeks to address.

It can be easier and more effective over the long run to integrate climate risks into existing practices than to create new frameworks.

Meteorological institutions, boundary institutions, and independent scientific arms of government can play a critical role in strengthening information management systems required for climate-resilient societies and ecosystems.

WRR EXPERT PAPER

MALINI MEHRA: "The continuing framing of climate change as an environmental issue is part of the problem why it gets short shrift in terms of policy attention.... Even now major national plans on infrastructure, transportation and city development in many countries have no climate analysis or risk assessment. . . . The myopia on climate change translates into national budgets that are too weak to address the mitigation and adaptation requirements of many areas of policy attention—from public health and housing to agriculture and coastal defense—increasing the vulnerability of the nation."

— Malini Mehra, Center for Social Markets

Box 5.1 Role of National Institutions in Enabling Local-Level Adaptation

National laws and regulations can create mandates or incentives for communities and local governments to undertake adaptation activities. Examples could include direct laws and regulations that call for specific adaptation activities, but they could also include land-use planning directives, zoning laws, tenure reforms, regulations pertaining to increasing market access, decentralization, migration and poverty reduction, and other types of natural resource management laws and policies, all critical to increasing resilience.

National-level governments and programs can build capacity and provide resources—and help communities and local governments access them—to support adaptation activities. These programs will also need to facilitate investments targeted to the most vulnerable, such as providing access to information that they can use.

National laws may underpin the legitimacy and sustainability of actions undertaken by local institutions, such as NGOs and user associations, which are instrumental in community-based adaptation.

National leadership can provide an example or create a national discourse to which communities respond by undertaking adaptation activities. The national level can also play a critical role in providing high-profile demonstrations in communication and in coordinating processes and partners.

National policy and institutional arrangements may also create barriers to adaptation at the local level or even lead to maladaptation. In this case, solutions to scaling up local-level adaptation may need national-level policy reform to reduce barriers or shift incentives away from poor practices.[5]

changing climate. On the other hand, flawed institutional arrangements, or those without sufficient capacity, can create stumbling blocks to efforts designed to increase resilience.

IMPORTANCE OF INSTITUTIONAL DESIGN IN A CHANGING CLIMATE

Each of the three kinds of change associated with climate change highlighted in this report (see Chapter 2) need to be managed by unique institutional capacities. When creating or reforming institutions to address climate risks, governments and donors should take into account the following factors:

Extremes will put a premium on responsive and nimble institutions that can manage a variety of both risk reduction and disaster response functions. These include the ability to collect and distribute timely information both before and in the immediate aftermath of disasters,[3] as well as to mobilize resources and promote service delivery to stricken areas.[4] These agencies also have a vital role to play in enabling community-level risk reduction measures, for example, by creating hazard maps that pinpoint regional and local areas of climate risk, informing action undertaken by local authorities (see also Chapter 6).

Heightened variability, such as altered rainfall patterns, will require flexible decision making to respond to and foresee evolving climatic changes on the ground and to implement actions accordingly. Much research has been conducted on what features make an institutional arrangement adaptive (see Box 5.2). In this report, we describe some additional and complementary lessons that have emerged from our research and can provide useful guidance for governments.

Long-term change will require institutions that can provide durable support to activities and yet be flexible enough to accommodate new priorities and information that emerge over time.

The risks that climate change poses will place a premium on institutions with strong coordination, leadership, and capacities to act. Such institutions will be better positioned to foster local-level action and improve outcomes on the ground. Below we explore specific ways in which institutions can be designed to coordinate across governance levels and sectors, foster leadership, plan for and respond to a variety of climate risks, and provide decision-relevant information (see Box 5.3). It is important to note that the design of institutions must go hand in hand with the adequate development of staff capacities, so that these institutions can carry out their intended tasks.

INSTITUTIONAL DESIGN FOR EFFECTIVE DECISION MAKING

Improved Coordination

Coordination will be essential across agencies, government levels—local, sub-national, national, regional, and international—and with stakeholders. These include civil society, the scientific and academic communities, the private sector, and affected communities. This will require extensive information sharing among those involved in decision-making processes so that each official recognizes the relevance and importance of addressing climate risks.

Effective coordination will help ensure that climate risks are incorporated into ongoing practices, such as budgeting processes, development plans, and sectoral policies and plans.

Effective coordination can also create a mandate for harmonizing priorities across relevant decision-making bodies, such as economic development, environment, and sector-based ministries. Institutional arrangements that enhance coordination can bring multiple benefits, helping to manage conflicts and trade-offs, prevent duplication, and avoid gaps in action that could have grave consequences for at-risk populations or sectors. This, in turn, results in improved efficiency and problem solving, both important factors for countries with few resources to spare. Such an approach can also help ensure policy coherence across governance levels and agencies and foster innovation and enhanced problem solving.

A kingfisher in the restored Rugezi wetlands of Rwanda.

Coordination Across Agencies

Coordination among national government agencies will also be an essential ingredient for effective decision making, given the cross-sectoral dimensions of adaptation needs. For example, changes in rainfall patterns can affect both agriculture policy and hydroelectricity planning. Such arrangements, however, have been slow to materialize.

A 2010 survey of 45 countries by UNDP found that only 46 percent had inter-ministerial committees or councils to manage climate issues. Of these countries, 52 percent of these committees sit under the Ministry of Environment, 43 percent under the President, Premier or Prime Minister's office, and 5 percent under the Ministry of Planning and Development. Overall, many of them lacked high-level political support.[7] Highlighting this failure, Bo Lim and Jennifer Baumwoll of UNDP argue that "Organizational change will happen when institutions recognize that the environment units can deliver better by working in partnership with other units, where the skills and experience for social systems often resides. 'Going it alone' is not an option if larger amounts of climate finance are to be delivered in the future without risk of fragmentation and duplication of efforts."[8]

Coordination across agencies can strengthen alignment among policy objectives and initiatives and prevent ministries from being at odds with each other. This can make a significant difference to results on the ground, as illustrated by efforts to implement measures to restore the Rugezi wetlands in Rwanda and increase hydroelectricity production after a long drought. Since wetlands drainage was a cornerstone of the country's agricultural policy (see also Rwanda case study p. 84), this priority interfered with the adoption of land use management policies for protecting the wetlands.[9]

Two sub-Saharan African countries have taken somewhat different approaches to coordinating their early efforts to plan for climate change impacts. The Government of Malawi houses the National Climate Change Programme (CCP) within the Ministry of Development, Planning and Cooperation (MoDPC), one of the key ministries in the national government. UNDP's African Adaptation Programme is aligned with and complements this national effort, in particular with support to capacity development and knowledge management around climate change. Under this structure, the MoDPC coordinates climate change activities in Malawi and strengthens the integration of climate change management in other sectors, with input from technical departments and ministries (Ministry of Natural Resources, Environment and Energy, among others). To ensure cross-sector integration and awareness, all policy and budget issues are overseen by the National

Box 5.2 Defining Adaptive Policymaking

Making institutions adaptive is easier said than done, particularly in the case of traditional, large-scale national government bureaucracies. A joint study undertaken by the International Institute for Sustainable Development (IISD) and The Energy and Resources Institute (TERI), based on more than a dozen policy examples, uncovered a number of governmental practices that help make them "adaptive." These include:

- Identification of key factors that affect policy performance and how they might evolve over time;
- Identification of key indicators that can help trigger automatic policy shifts;
- Regular review of policy outcomes;
- Using a range of activities to increase the likelihood of achieving desired goals;
- Pursing a multi-stakeholder collective and collaborative effort to examine an issue from different points of view;
- Facilitating conditions under which stakeholders can network, organize, and share good practices; and
- Decentralizing decision-making to the lowest effective and accountable unit of governance.[6]

Box 5.3 The National Adaptive Capacity Framework

To assist with the development of strong institutions to support adaptation, the World Resources Institute and its partners have developed a typology of critical institutional functions that countries will need to perform in order to adapt effectively over the long term. Called the National Adaptive Capacity (NAC) Framework, this typology can be used for assessing the institutional capacity of a national government. The NAC has been piloted through assessments in Bolivia, Ireland and Nepal during 2009 and 2010.

An assessment using the NAC Framework can provide a "snapshot" of a country's institutional strengths and gaps with regard to adaptation. This can be used as a baseline for adaptation planning that can help improve adaptation in a particular country, according to its unique needs and circumstances. The NAC can be used by planners (such as planning commissions), evaluators (such as ombudsmen or parliamentarians), or advocates (such as civil society groups).

The institutional functions that the NAC framework identifies are organized around five categories (assessment, coordination, prioritization, information management and risk reduction). For each of these categories, the NAC offers questions that assess a country's ability to perform key tasks. Based upon the answers, decision makers can identify priorities for building institutional capacity or identify areas where adaptation could move forward quickly based upon existing strengths. Later, a second NAC assessment could be undertaken to review progress.

In Bolivia, researchers at Nur University used the NAC to assess progress and found that the Ministry of Planning had a clear mandate to lead in mainstreaming climate change issues in national planning. The assessment also found that the National Mechanism on Adaptation (MNACC) had enhanced horizontal coordination between the Ministry of Environment and other sector Ministries. However, there was a general lack of vertical coordination with lower levels of governments like provincial and municipal bodies despite the initiation of a legal process to strengthen municipal and provincial functions. Based on their NAC assessment, the Nur researchers recommended that enhanced coordination was critical to streamline actions and use resources more effectively.

—Heather McGray and Aarjan Dixit, WRI

WRR EXPERT PAPER

JOHAN ROCKSTRÖM: **"Countries' governance systems are split. Water is governed primarily by Ministries of Water Resources, which are 'wet,' and agriculture is governed by Ministries of Agriculture, which are 'dry' (i.e., despite governing the sector consuming the largest volumes of freshwater in human societies, [they] are mainly responsible for policies related to crops and land). Ministries of Agriculture need to become much more 'wet' in their governing approach and invest much more competence in how to promote, for example, small-scale water harvesting systems."**

— Johan Rockström, Stockholm Environment Institute and Stockholm Resilience Center

Steering Committee on Climate Change, composed of senior representatives of the most relevant sectoral ministries and chaired by MoDPC. Development partners are involved through the National Climate Change Working Group, co-chaired by MoDPC and the UN Resident Coordinator.

In Burkina Faso, a permanent secretariat has been created in the country's National Council for Environment and Sustainable Development. The Secretariat is responsible for coordinating the implementation of climate change adaptation projects. Cross-sectoral and multi-sectoral projects, however, are still supervised by the Ministry of Environment.[10]

Coordination of adaptation and disaster risk reduction activities is also critically important. Institutions charged with addressing climate change are typically associated with Ministries of the Environment or national meteorological services.[11] These institutions tend to be disconnected from national platforms to manage disaster risk, where they exist, as well as from development policy. Government efforts to coordinate disaster risk reduction with national and sectoral planning can help address this hurdle. For example, in Bangladesh, the Comprehensive Disaster Management Programme implemented over the past decade has led to the incorporation of disaster risk reduction into both the national poverty reduction strategy and the development planning process. In addition, the Ministry of Food and Disaster Management has been charged with integrating disaster management into the activities of other government ministries.[12] In a similar fashion, the South African government, responding to major floods in 1994, adopted a Disaster Management Act, which created a mandate for integrating disaster risk reduction into sectoral strategies.[13]

Coordination Across Levels of Government

Given the broad geographic impacts of climate change, coordination will also be required across all levels of government. In many cases, national-level governments will also need to provide the support and enabling conditions for local governments to build the capacity necessary to address the challenges associated with climate change. For example, responding to extreme events will require close collaboration between national and local governments to assist those affected.[14] Some examples of such coordination at work are found in the WRR case studies highlighted throughout this report, and summarized below.

In Bangladesh, partnerships with sub-national governments and institutions were a critical ingredient in the nation's innovative nationwide disaster management activities. Today, over 75 sub-national organizations are part of a nationwide network that began a decade ago in seven pilot districts.[15]

In Namibia, a pioneering approach known as FIRM (Forums for Integrated Resource Management) has enabled local constituencies to take ownership of decisions vital to their livelihoods while enabling two-way information exchange with government agricultural extension officials. At FIRM meetings, held either monthly or quarterly, community organizations share the results of locally run monitoring programs for farming and livestock health, while government representatives share information about government agricultural and other policies and programs. Joint courses of action can also emerge from these meetings, such as adopting communal herding to address a shortage of land for grazing, although it is the local community that makes the final decisions.

In Central Kalimantan, Indonesia, coordination between the national, provincial and local levels was critical to the success of a predictive warning system for peatland fires exacerbated by the El Niño to improve management of controlled burns. Decisions were made at provincial level but implemented at the district and village levels most knowledgeable about local circumstances. Indeed, a key ingredient for the program's adoption by government decision makers was the development of clear roles and responsibilities across various levels of governance.[16]

STRENGTHENED LEADERSHIP

The choice of which government agencies and individual leaders direct and coordinate adaptation activities can significantly impact outcomes.[17] If the power to coordinate rests in the Ministry of Environment, as opposed to an office in the president or prime minister's office or departments that have broad national responsibilities for development and other goals, weak outcomes can result.[18] High-level political endorsement and government mandates, on the other hand, can catalyze action, task agencies and sub-national governments to integrate risks into practices, and create frameworks for collaboration and consistency across government efforts.[19] Strong leaders often not only define the scope of policy and planning activities but also maintain momentum and quality.[20]

Fire is used in Kalimantan Province to clear land.

Embed Responsibilities in Powerful Institutions

Cabinet-level officials and Ministries of Finance or Planning, powerful agencies that set national priorities, typically have not been involved in adaptation efforts. Yet their engagement can be essential to gaining the authority and legitimacy to direct large-scale adaptation activities for sustained periods of time. China provides two telling illustrations, both highlighted in case studies for this publication. In the first instance, extensive flood management measures for the Yangtze River, which included the relocation of more than two million people, were led by China's State Council via the powerful, cross-sectoral National Development and Reform Commission, chaired by the Vice-Premier. While jointly implemented by relevant sectoral officials, the authority provided by the State Council was a key factor ensuring cooperation among the many government agencies involved.[26] Similarly, Chinese measures to enhance the resilience of crops to climate change across its agriculture sector are being led by the State Office of Comprehensive Agricultural Development, an influential body in the provinces and among government agencies.[27]

Gain Commitments from Powerful Leaders

In addition to leadership at the agency level, the commitment of individual leaders can play a key role in policy effectiveness. For example, in Bangladesh, the influential Secretary of the Ministry of Food and Disaster Management assumed the position as National Project Director of the country's disaster management program. While the choice of ministry matters when selecting leaders, the high-level stature of the individual (in this case, the Secretary of the Ministry) also can make a difference in outcomes. "Having the most senior person at the Ministry as the director ensured that decisions made by the project director were implemented and staff was held accountable," reported the authors of the WRR Bangladesh case study. Such high-level ownership of adaptation initiatives is particularly important given that trade-offs often have to be made, involving winners and losers among affected constituencies, and that decisions made to provide long-term climate resilience will at times cause short-term hardships.

Governments, donors, and civil society organizations can also foster leadership among public officials lower down the ranks by publicly recognizing and rewarding their achievements.[28] For example, the World Wildlife Fund facilitated awards and media coverage for public officials and

WRR EXPERT PAPER

BO LIM AND JENNIFER BAUMWOLL:

"Given the close linkages between climate change policies and development priorities, and the increase in climate change financing, there is a need to place the climate change agenda within prominent institutions, such as ministries of finance and planning, ministries of economic development and trade and other leading government institutions. For example, in Japan climate change is now sitting under the responsibility of the powerful Ministry of Economy, Trade and Industry (METI) and is high in the political agenda. In Canada, a multi-sectoral Task Force on Climate Change was created, rather than leaving the climate change agenda to the Environment Protection Agency."

— Bo Lim and Jennifer Baumwoll, UNDP

government agencies who adopted measures that improved livelihoods and ecosystem management as part of the Yangtze River floodplain restoration effort in China. Incentives like these need not require significant financial resources or donor involvement; often, prestige and recognition can go a long way.

IMPROVED PLANNING AND POLICYMAKING

Planning and policymaking in a changing climate are filled with complexities, including the need to respond to the distinct types of change identified in this report and to the uncertainty associated with future impacts. Examples of important institutional functions and related designs from a planning and policymaking standpoint are described below.

Integration of Climate Risks into Existing Policy and Planning Frameworks

It can be easier and more effective over the long run to integrate climate risks into existing practices than to create new frameworks. In one example of this pragmatic approach, South Africa's government has begun to integrate climate risks posed to biodiversity and ecosystems into spatial planning (see South Africa case study p. 116). Provincial authorities now use biodiversity sector plans, which include maps of species and ecosystem hot spots and corridors, to help guide land use planning in the housing, agriculture, conservation, and industry sectors. These plans are increasingly taking into account climate change impacts, a shift made easier by the existence of dedicated policy and planning frameworks and legal requirements—in this case, the required use of biodiversity plans—which provided strategic entry points for change.[29] Similarly, development agencies can work to leverage existing development strategies and mainstream climate risk into countries' economic development and sectoral programs.[30]

Rapid Response

In the aftermath of an extreme event, planning agencies must be able to react quickly. Lean institutional arrangements and the effective deployment of information and communication technologies can facilitate the swift and efficient distribution of aid to afflicted areas. Bangladesh, for example, has established a Disaster Management Information Center (see Box 5.5) that rapidly collects and distributes information whenever major flooding, cyclones, or other significant weather events occur.

Similarly, but on a regional level, the Acre State government in Brazil has established a "situation room" that quickly processes satellite and airplane reconnaissance data related to fire and weather events and coordinates responses, including targeted fire-fighting operations. Initially set up after devastating forest fires in 2005, the situation room was resurrected in 2006, 2009, and 2010 after floods submerged land outside Rio Branco, the capital of Acre State, demonstrating that similar institutional arrangements can be effective in responding to different types of extreme events.[31]

Continuous Opportunities for Update

How can policymakers reconcile the contradiction of creating institutions that are long-lasting and durable and yet adaptive enough to respond flexibly to new information? A promising solution is to combine these characteristics in a single institution that works over long time horizons but with provisions in place to make regular policy adjustments as circumstances dictate. For example, the flood management measures for the Yangtze River described earlier were enabled by a planning process that was both long-term and iterative. China's objectives and targets for the region are rooted in a 30-year master plan that was carried out in five-year implementation plans. Responsibility for meeting specific project goals is assigned to relevant agencies, and the performance of officials is measured against these objectives.[32] This arrangement builds in opportunities for learning and incorporating new information, which in turn can lead to improvements.[33]

Box 5.4 Leadership and Government Action in the Small Island State of Kiribati

Kiribati, a small island state located in the South Pacific, is highly vulnerable to the effects of climate change. According to one World Bank study, Kiribati may incur annual costs of US$8 million to $16 million by 2050, due to climate change and sea level rise if no adaptation measures are taken.[21] This would represent 5.9 to 11.9 percent of national GDP in 2008.[22] The Kiribati Adaptation Project (KAP), a three-stage, multi-year project funded by the World Bank and the Global Environment Facility, seeks to avoid such an outcome by implementing pilot adaptation measures and mainstreaming adaptation into national economic planning.

Initiated in 2003, KAP is composed of three phases—the first phase geared toward preparation, the second focused on pilot implementation, and the third focusing on expansion and scaling up. The project aims to build government capacities for adaptation; two major goals of the project are to appoint a secretary and a deputy secretary in charge of coordinating adaptation activities across ministries and to integrate systematic climate risk management into 60 percent of the ministry's operational plans.[23]

As of June 2011, project activities included construction of seawalls to protect major roads and airport runways, the planting of additional mangroves to build shoreline resilience, the development of a water master plan, and the deployment of rain gauges in previously unmonitored locations, among other activities.[24] At the time of this report's release, the project was nearing the end of the second phase; the final phase of KAP is expected to be completed in 2015.[25]

Box 5.5 Improved Disaster Response In Bangladesh

The Bangladesh Disaster Management Information Centre was established to increase emergency response and information management. It operates 24/7 during emergency situations. This allows it to monitor and report on natural hazards as they unfold, including earthquakes and tsunamis. This has been accomplished by the creation of telecommunication links with all of the nation's 64 districts and 235 upazila centers considered high risk. These telecommunication links are referred to as the Disaster Management Information Network, which also has a web portal. The Disaster Management Information Centre also provides IT support to the Bangladesh Meteorological Department and the Flood Forecasting and Warning Centre. The Terminal Evaluation of the Programme asserts that this assistance . . . has increased the timeliness and effectiveness of flood warnings.

— Kirsten Luxbacher, USDA, Abu Kamal Uddin, UNDP. WRR Case Study

Long-Lasting Mandates

Planning for a changing world can be enhanced by the embrace of long-lasting mandates, or obligations, to act. Mandates that are in force over decades can help ensure the continuity of adaptation actions, despite the turnover of governments and officeholders. This is likely to be critically important to effective decision making, especially as climate risks will be a key focus of government and society for decades to come.[35] Precedents exist, with many sectoral plans made with longtime horizons in mind. For example, South Africa's National Transportation Master Plan spans 2005 to 2050 (see Box 5.6).

Such long-term mandates may need to be coupled with incentives (see also Chapter 3 on public engagement) to encourage follow-through on action and to build the support of affected communities and other constituencies. This is particularly important where the need for action may not be obvious (for example, sea levels in vulnerable low-lying areas that are not visibly rising) and where government-imposed actions involve short-term disruption in order to achieve longer-term gain (for example, directing development away from flood-prone areas). In South Africa, landowners who set aside acreage to protect the resilience of biodiversity are given tax deductions and property tax rebates. In Vietnam, the long-term viability of mangrove restoration efforts improved when communities were allowed to manage the mangroves for multiple uses and received other benefits (see Vietnam case study, p. 43)

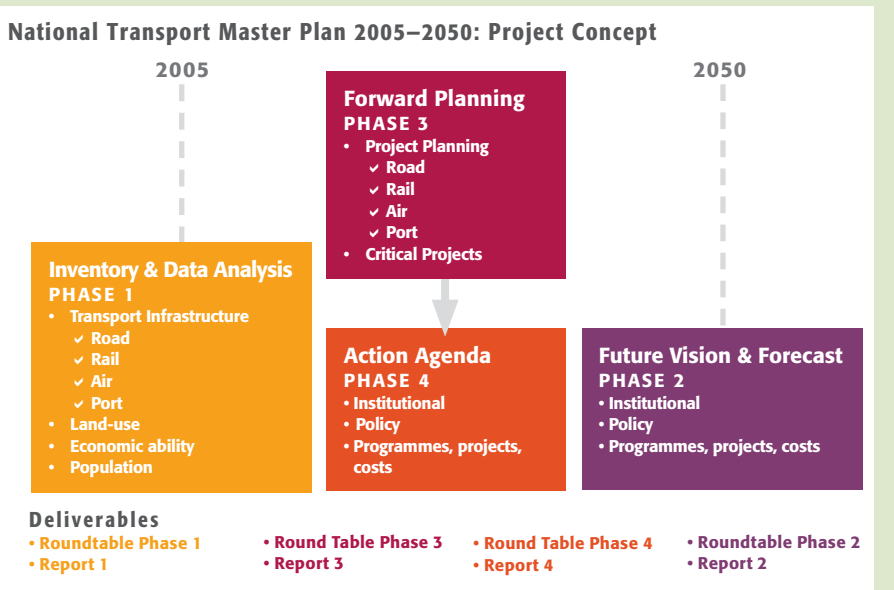
Long-term mandates are not only helpful for preparing for long-term change but also for government responses to extreme events. While the initial response to disasters will often fall within a public official's time in office, the short-term nature of the political cycle can result in short-term efforts [36] that wane after the event subsides. To address this problem, risk reduction efforts, as well as relief and recovery initiatives, can be incorporated into long-lasting government mandates—with assured funding—that require constant monitoring, evaluation, and innovation.

Governance of climate change will also require measures to address institutional turnover. In Bangladesh's Comprehensive Disaster Management Programme, both frequent turnover of and the failure to pay government officials proved problematic for capacity development and engagement purposes. Over five years, there were no fewer than seven Secretaries and five Directors General of the Disaster Management Bureau.[37] This, in turn, led many organizations and individuals to view the program with skepticism, and it took approximately 18 months to get the project through its initial phase.

Box 5.6 Long-term Planning in South Africa's Transportation Sector

South Africa's National Transport Master Plan 2005–2050 provides an illustrative example of an adaptation-relevant policy process with a long-term mandate. Lanfranc Situma, the project manager, elaborates:

"The government has developed forecasts of high, middle, and low growth scenarios for GDP and population growth to assist in this planning. As of late 2009, the project had completed initial data analysis and begun a future modeling phase (Phase 2 in the diagram)."[34]



PROVIDING INFORMATION

As described in detail in Chapter 4, decision-relevant information is of critical importance to the effectiveness of planning and policymaking in a changing climate. Institutions can play an important role in strengthening information management systems to collect and disseminate the information required to build climate-resilient societies. While not the focus of our research, the importance of local institutions in collecting and disseminating information to both those affected and the national government cannot be underestimated. Local authorities, as well as non-governmental organizations play a vital role in both translating national information to a local setting and acting as an information conduit between local sources of knowledge and the national government.[39] Crispino Lobo of the Watershed Organization Trust, an Indian rural development NGO, writes, "While public agencies may be better placed in understanding the science of climate change and how it will likely impact people, competent and experienced NGOs are usually best placed in not only devising adoptable technical and social adaptive strategies but also coordinating and mediating best practices and promising technologies at the community level as well as providing feedback to related public agencies."[40] To this end, national governments will need to create the conditions and incentives that both encourage links between national and local institutions and strengthen and empower local institutions to collect and provide information.

Our research has identified several approaches to developing or strengthening institutions to perform the vital functions related to information management.

Meteorological Institutions

As discussed in Chapter 4, the data provided by meteorological institutions can aid in the development of forecasts and provision of timely information. Meteorological institutions are staffed with technical experts and are well placed to develop innovative ways to collect and disseminate information. Our research provides several examples:

As described in Chapter 4 on information, the Zambia Meteorological Department has led the implementation of the innovative RANET (Radio and Internet for the Communication of Hydro-Meteorological Information for Rural Development) project, which successfully provides climate and weather information to remote rural areas with the use of mobile phones and communication satellites, among other devices.

In Mali, the National Meteorological Service, the Direction Nationale de la Météorologie, has provided seasonal rainfall forecast data to 2,000 farmers, enabling them to take actions to maximize crop yields despite altered rainfall patterns.

The peatland fire predictive tool developed in Central Kalimantan, described earlier, was established in partnership with the Indonesian Meteorological Service, which also helped validate satellite data against local data.

Many meteorological institutions, however, have few resources and no mandates to assist in gathering decision-relevant climate data. Cost-effective investments can and should be made to strengthen and create meteorological institutions as a matter of priority.

Boundary Institutions

Meteorological and other agencies can also play important roles as "boundary institutions," or intermediary organizations that sit at the boundary of science and policy and synthesize and translate scientific findings for decision makers and the public.[41] Since they have the technical expertise to understand relevant information, they can convert knowledge into practical guidance.[42] Boundary institutions often also assess the policy implications of scientific research, make information locally relevant and accessible, and maintain dialogue among stakeholders (see Box 5.8).[43] These boundary institutions can be local universities, non-governmental organizations, extension services. Institutional arrangements that facilitate exchange among government officials, stakeholders, and boundary institutions can maintain the flow of decision-relevant information and hasten action.[44]

Box 5.7 How Donors Can Assist National-Level Institutions

Donor agencies, including OECD governments, multilateral development banks, and UN institutions, provide support for national-level adaptation efforts in many developing countries. This includes, for example, financial and capacity support for developing and implementing National Adaptation Programmes of Action (NAPAs).

Often, however, donor support has been channeled into sectoral planning and policymaking for climate change, reinforcing a bias by developing country governments that fails to recognize the cross-sectoral nature of the issue or the need to mainstream climate risks into national development planning.

As Mike Muller, former Director General of South Africa's Department of Water Affairs and Forestry, pointed out in a WRR expert paper, "Donor programmes are also often themselves sectorally focused and may avoid collaborative and cooperative approaches. To date, many adaptation support programmes have fallen into this trap."

Richard Muyungi, Assistant Director of Environment in the Vice President's Office of the United Republic of Tanzania, comments in the same paper series, "Development agencies have traditionally focused on specific areas of support for a number of reasons; hence coordination of development agencies' support at national level is still a challenge and needs to be improved."

However, donor agencies are increasingly recognizing the limitations of current approaches. Bo Lim, Principal Advisor on Climate Change, Development and Adaptation at the United Nations Development Programme (UNDP), and her co-authors concede in a WRR expert paper that "due to the top-down requirements of global funds, adaptation has struggled to link climate change with development. As a result, adaptation actions tend to focus on stand-alone pilot projects that are isolated from national planning processes. Ideally, the National Adaptation Plans . . . should align with national priorities."[38]

Box 5.8 Boundary Institutions: Bridging the Gap between Government, Farmers, and Climate Experts in Mali

"In 1982, following a decade of severe drought, Mali's National Meteorological Service initiated a project to provide poor farmers with seasonal climate information. The aim was to help farmers manage risks to crop production associated with variable rainfall.

Ultimately, the project has shown that science, notably the increased skill of seasonal forecasting, could be used to provide farmers with a longer lead-time for their decision-making. . . . A particularly important role has been played by the project's multidisciplinary working group, which has served as a boundary institution by 'translating' climate data into practical advice. . . . The group, which meets regularly, includes representatives from the meteorological service, the Ministry of Agriculture, agricultural research institutes, rural development agencies, farmer groups, and the media. To help ensure that Malian farmers are able to use climate information to make decisions about their livelihoods each member provides specific inputs:

- Farmers define the climate-related data and products they need.
- The Meteorological Service analyzes technical aspects of these data and products.
- The Ministry of Agriculture, extension services, and research groups work on issues related to food production, crop health/protection, and choice of crop varieties.
- The rural development agencies focus on capacity building and information dissemination.
- The media publicizes climatic and agrometeorological information."

— Molly Hellmuth, Daouda Zan Diarra, Catherine Vaughan, Remi Cousin, WRR Case Study

WRR EXPERT PAPER

TONY LA VIÑA: "The uncertainties that characterize climate change . . . underscores the importance of quality information and accurate data in the planning process. . . . One huge challenge that needs to be addressed is how to bridge the gap between scientists and planners, transforming what science tells into a clear, strategic, and sound policy, and translating data and scientific studies into concrete plans and programs."

— Tony La Viña, Ateneo School of Government, WRR Expert Commentary

Independent Scientific Arms of Government

The ability of policymakers and planners to interact with scientists in relevant disciplines can be a key factor in the effective integration of climate risks into decisions. Institutional arrangements may either create bottlenecks to scientific input into the policy process or facilitate this critically important exchange. Research has shown that government scientific agencies are more likely to advance adaptation policy when they have a mandate to promote the implementation of their research and are independent, stand-alone institutions.[45] In South Africa, for example, the government-run South African National Biodiversity Institute was a catalyst for the integration of climate risks to ecosystems into planning. The Institute's broad mandate includes science policy and implementation.[46]

For policymakers and planners working in the kinds of institutions described above weighing how to respond to and prepare for different types of climate change, a variety of decision-support tools can be useful. The next chapter describes both commonly used and innovative tools that show promise for supporting plans and policies for a changing climate.

BRAZIL: Fire and Flood Responses in the Amazon

IN BOTH 2005 AND 2010, THE STATE OF ACRE IN THE BRAZILIAN AMAZON SUFFERED DROUGHTS OF "ONCE in a century" severity.[1] In both years, the consequences included extensive wildfires caused, in some cases, by pasture management fires escaping control and, in others, by deliberate deforestation activities. The fires raged from July into October, even penetrating nearby virgin and degraded forests.[2] In 2005, the economic, social, and environmental losses reached nearly US$100 million. In addition, the drought had a major impact on forest productivity and significantly reduced carbon stocks. Estimates of damaged forest ranged from 267,000 to 417,000 hectares.[3]

As a result, the 2005 drought triggered an innovative, centralized response by Acre authorities to monitor wildfires and prioritize firefighting efforts. This action was then deployed again during the 2010 drought and also used by the state government to respond to flooding emergencies.

Foster Brown, Woods Hole Research Center, Graduate Program in Ecology and Natural Resource Management of the Federal University of Acre

George Pereira Santos, Military Firefighters Corps of Acre State, Brazil; Municipal Civil Defense of Rio Branco, Acre, Brazil

Carlos Batista da Costa, Military Firefighters Corps of Acre State, Brazil

Flavio Ferreira Pires, Military Firefighters Corps of Acre State, Brazil

THE SITUATION ROOM

In 2005, the first signs that a major drought was affecting Acre, Brazil's westernmost state, became apparent in May, although the state authorities did not institute a ban on farmers' setting fires until August. At the same time, as fires raged across the region, officials set up an emergency response "situation room" to monitor the fires' status, coordinate the relevant government offices' activities, and direct firefighting resources to high-priority areas.

The effort was led by the State Civil Defense in collaboration with the State Firemen Corps (CBM) the State Environmental Secretariat (SEMA/AC), and the Environmental Institute of Acre (IMAC). Using satellite data on the fire activity and information gathered by daily overflights, the situation room held daily briefings to coordinate the deployment of firefighting crews, giving priority to protecting the rural population and infrastructure.

Accurate real-time satellite data were critical to directing successful fire-fighting efforts.

Volunteer researchers from the Federal University of Acre who were experts in analyzing satellite data also joined the effort, studying imagery from sources such as NASA and NOAA* and also aerial photography from overflights of eastern Acre.

Since the scale of the fires was well beyond the capacity of state and municipal civil defense units to control—with only 400 firefighters at their disposal—the situation room was used mainly to target the firefighting where it would be most effective.

Five years later, when the first signs of a major drought again appeared, the Acre government, having learned from the 2005 experience, responded more quickly. A state of emergency was declared in early August, and the situation room was reactivated. Again the goal, given the limited resources, was to direct the firefighting responses to critical areas. On both occasions, the situation room was disbanded in October after the rains began and the fires were extinguished.

In both 2005 and 2010, even though the situation room failed to control fires across rural areas, it did achieve its stated goal of protecting the well-being of the state's sparse rural population by preserving village properties. With only 30,000 to 40,000 rural families scattered across the 160,000-square-kilometer state—an area three times the size of Costa Rica—precisely targeting those in need was essential to preserving settlements and livelihoods.

Based on its performance in 2005, the situation room model has also been adopted by other levels of government in response to other extreme weather events. Accordingly, short-term situation rooms were activated in 2006, 2009, 2010, and early 2011 by the city of Rio Branco (the capital of Acre) to target emergency responses to flooding in various parts of the state.

LESSONS LEARNED

The risks of severe droughts and an ever-growing deforested area, much of it grassland, has made Acre more vulnerable to fires and water shortages. In particular, the unusual nature of two major 100-year droughts within six years has raised concerns about the long-term resilience of the Amazonian ecosystem and heightened awareness of the need to control burning for agricultural activities.[4]

Such vulnerability, however, can be addressed with innovative public policies to control fire and to find fire-free alternatives to agriculture and pasture management. The state government, which has been in power since 1998, has responded to this challenge by promoting innovative public policies designed to reduce deforestation and burning, including the situation room approach. (Other examples include a 2008 state plan to control deforestation and a memorandum of understanding signed in November 2010 by the states of Acre, California (United States), and Chiapas (Mexico), to develop a program of carbon credits for avoided deforestation).

In addition to government leadership, the situation room's success in directing firefighting activities depended on the availability of accurate, real-time satellite data and the ability to use this information in decision making. Here, the situation room's partnership with expert researchers was critical. All the local university-based technicians and scientists who aided the firefighting effort were active or former researchers of the Large-Scale Biosphere Atmosphere Experiment in Amazonia (LBA), a series of studies in regional climate, land use changes, and forest dynamics.[5]

Pressure by the media and civil society to reduce the raging fires—which in both 2005 and 2010 blanketed urban populations in eastern

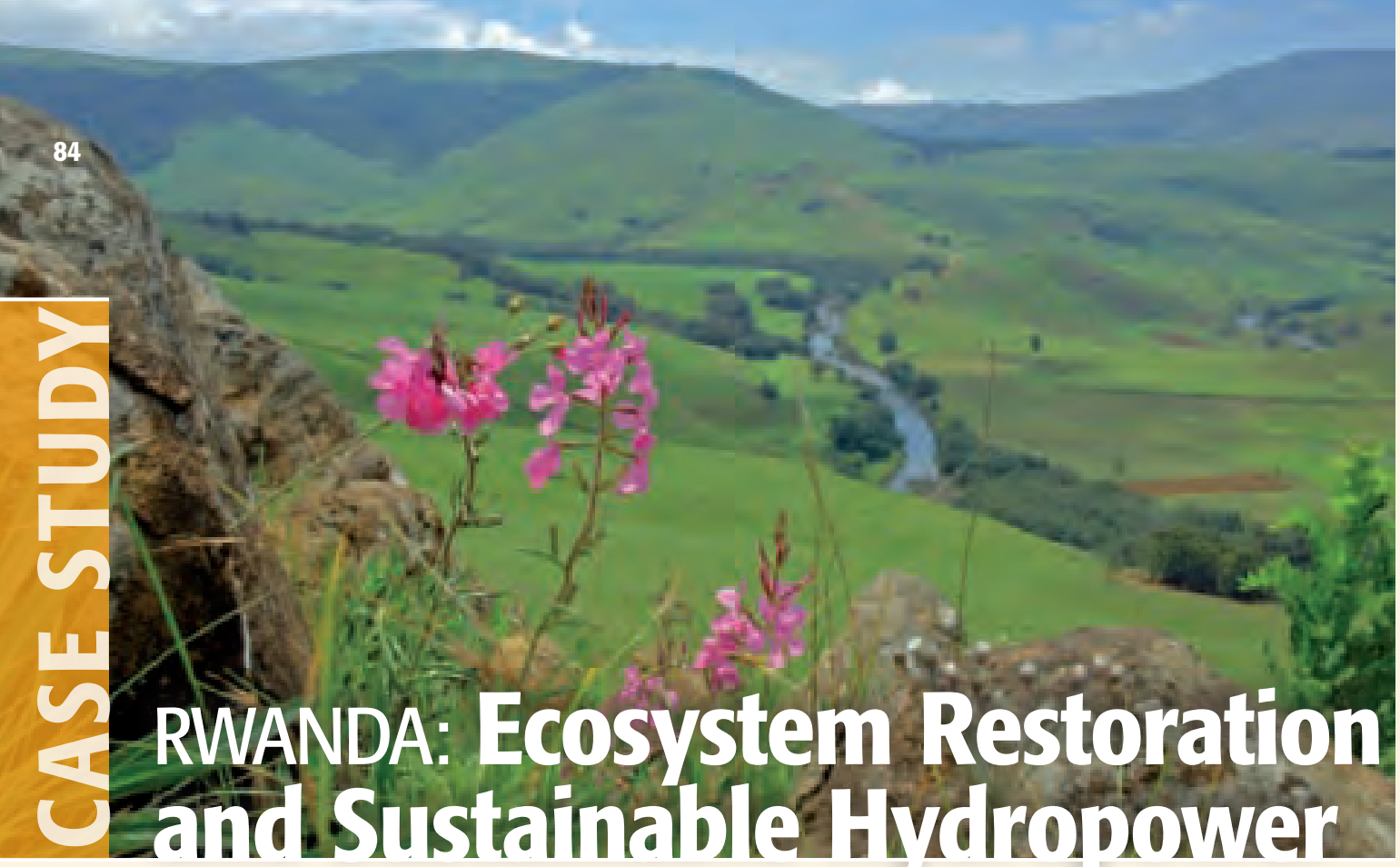
Acre in a health-threatening smoke haze—also helped prompt the government's timely and effective response. For emergency responses and adaptation planning in the future, the increased likelihood of natural disasters, including flooding, droughts, and the resulting fires, will require even broader policy approaches.

For example, the use of fire is culturally embedded and economically cheap in Acre, and to date, the effective dissemination of alternatives to the use of fire has been limited. In addition, the state's limited enforcement capacity, coupled with difficulty in proving responsibility, has meant that few rural inhabitants are prosecuted for setting fires during periods of prohibition, despite the huge damage they can cause. The state authorities are now working with national government ministries to eliminate the use of fire as a land management tool and to find alternatives for rural farmers.

ENDNOTES

1 Xu et al. 2011.
2 Brown et al. 2006a; Authors' personal observations.
3 Brown et al. 2006b; Shimabukuro et al. 2009.
4 Lewis et al. 2011.
5 Selhorst et al. 2003; Mendoza 2003.

* NASA is the United States National Aeronautics and Space Administration. NOAA is the United States National Oceanic and Atmospheric Administration.



CASE STUDY

RWANDA: Ecosystem Restoration and Sustainable Hydropower

IN RWANDA, THE PRODUCTION OF HYDROELECTRIC POWER IS REGARDED AS CRITICAL TO ACHIEVING THE country's economic development and poverty reduction goals. The "Land of a Thousand Hills," with its numerous rivers and lakes, is highly suited to water-based energy generation to meet the surging demand for electricity from its expanding population, urban industries, and rural agroprocessing investments.

Hilary Hove, Jo-Ellen Parry, International Institute for Sustainable Development

Nelson Lujara, Ministry of Infrastructure, Rwanda

As of 2010, only 10 to 11 percent of households in Rwanda had access to electricity. The country's 2011–2017 Energy Policy and Strategy sets an ambitious target of ensuring that access will expand to 50 percent of households by 2017.[1]

Although hydropower plants have the lowest production costs for electricity in Rwanda, reliance on this energy source presents challenges. Among them is the fact that it makes power generation vulnerable to changing hydrological conditions, such as those likely to occur as climate change intensifies.

This vulnerability was demonstrated in 2003/2004 when Rwanda experienced an electricity supply crisis that damaged its development prospects and resulted in a sharp decline in electricity production for many years. The government responded with ecosystem restoration measures that may offer lessons for other areas of Rwanda and countries vulnerable to changes in water systems due to several factors, including climate change.

This case study points to the potential for trade-offs between short- and long-term adaptation goals.

The electricity crisis was triggered by a steep decline in power generation at the Ntaruka hydropower station, one of two stations that together generated 90 percent of the country's hydroelectric power in 2004. The problem was caused by a significant drop in the depth of Lake Bulera, Ntaruka station's reservoir. The water loss was precipitated by a combination of factors, including poor management of the upstream Rugezi wetlands, degradation of the surrounding Rugezi-Bulera-Ruhondo watershed due to land fragmentation and the over-cultivation of crops and livestock, poor maintenance of the station, and less rainfall over the previous few years. The declining health of the watershed was also adversely affecting local livelihood activities such as fishing, transportation, and the production of handicrafts.

The drop in Ntaruka's capacity to produce electricity forced Rwanda to install diesel generators, whose operation cost the country up to US$65,000 per day.[2] Electricity rates doubled from 2004 to 2005, from 7 to 14 US cents per kilowatt-hour and rose again in 2005/2006 to 22 US cents per kilowatt-hour.

Beginning in 2004, the Rwandan government sought to restore the degraded watershed by halting the ongoing drainage activities in the Rugezi wetlands. It also banned agricultural and pastoral activities along the wetland's shores, as well as those of nearby Lake Bulera and Lake Ruhondo. Specifically, the government restricted agricultural and pastoral activities to 10 meters from the banks of streams and rivers and 50 meters from the banks of lakes. The Rugezi-Bulera-Ruhondo area also was recognized as a Ramsar Wetland of International Importance in December 2005, and the Rwandan government designated the Rugezi wetlands as a protected area in 2008.

These actions were enabled first by the country's existing environment policy (2003) and subsequently by its national land policy (2004), environment law (2005), and land law (2005).

PROMOTING SUSTAINABLE LIVELIHOODS

These actions, however, left many of the region's poor rural and landless households unable to access key resources. According to one source, nearly 70 percent of Rugezi's population had cultivated land in or near the wetlands before the new restrictions went into effect, but no compensation was made available to those who had lost access to this land. In response to public concerns about the loss of livelihoods, the Rwandan government instituted additional agricultural and watershed management measures to offset the adverse impacts of the conservation measures, including:

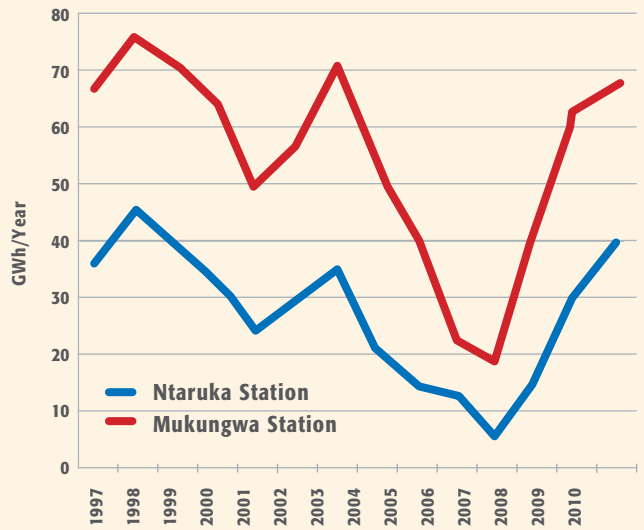
- Promoting environmentally sustainable farming practices.
- Planting trees and building erosion control structures on surrounding hillsides.
- Distributing improved cookstoves.
- Promoting environmentally sound farming practices and additional income-generating activities such as beekeeping.

Implementing these activities involved various government ministries, including those responsible for the environment, agriculture, livestock, forestry, and defense.

Over time, the combination of policy interventions and complementary restoration activities has contributed to the gradual rehabilitation of the Rugezi wetlands and an increase in the nation's production of hydroelectricity. The wetlands' filtering capacity was enhanced, reducing siltation rates and increasing water flow into Lake Bulera. Other actions, such as alternating the use of turbines at the Ntaruka hydropower station also led to rising levels in the lake. A milestone in Rwanda's efforts was reached in October 2007 when Ntaruka again began to operate fully. By 2009, its power production had reached a capacity of 7 megawatts.[3]

The degree to which the specific laws of 2005 are responsible for the ecosystem's restoration is debatable. Some sources indicate that the 10-meter and 50-meter rules were not adequately enforced in Rugezi; the government's State of the Environment report makes the same admission with respect to the application of these rules throughout Rwanda's wetlands.[4] But it also has been suggested that local authorities have discretion over the laws' implementation,[5] thereby creating the possibility for stricter enforcement in Rugezi, given their importance to the country's broader energy concerns.

Power Production from the Ntaruka and Mukungwa Hydropower Stations (GWh/Year)



Source: RECO (formerly Electrogaz) 2011.

The impact of efforts to restore the Rugezi-Bulera-Ruhondo watershed on the local population is a more difficult question. Initially, many local livelihoods were adversely affected as households lost access to the land for cultivation. Since this time, however, the restoration efforts appear to have started to provide some benefits. Radical terracing and agroforestry activities have increased crop productivity; grasses planted on managed terraces and lake banks are providing fodder for livestock; flora and fauna have increased in the Rugezi wetlands; and ecotourists are now visiting the area. The full consequences of the watershed restoration efforts on local people will only become clear over time.

LESSONS LEARNED

The factors leading to Rwanda's 2004 electricity crisis and the multiple actions taken by the government in response offer a number of lessons for energy security and for adaptation decision making.

One of these lessons is the value of an integrated approach to solving complex problems. Restoring the Rugezi-Bulera-Ruhondo watershed required interlinked efforts to address ecological, social, economic, and cultural issues, which were complemented by the electricity sector's efforts to improve its performance and management. The cooperation of ministries and actors on the national, district, and local levels also was important.

Although Rwanda's policies and actions were not explicitly designed to do so, improving the health and function of the Rugezi-Bulera-Ruhondo watershed should make the country more resilient to climate change. Land use management practices that minimize soil erosion and protect sensitive ecosystems often are critical to reducing vulnerability to climate shocks and stresses.

Finally, this case study points to the potential for trade-offs between short- and long-term adaptation goals, as well as the need for intermediary measures to mitigate adverse short-term impacts on local populations.

ENDNOTES

1 MINIFRA 2010.
2 UNEP 2006.
3 MINIFRA 2009.
4 RMNR n.d.; Willetts 2008a.
5 Pottier 2006a.

CHINA: Adaptation to Climate Change in China's Agricultural Sector

CHINA'S 3H PLAIN IS CRITICAL TO THE COUNTRY'S AGRICULTURAL ECONOMY AND THEREFORE TO ITS food security. The 350,000 square kilometers covering parts of five provinces and the major cities of Beijing and Tanjian contain one-quarter of the country's arable land and feed almost one-third of China's people. Yet its future productivity is in doubt, due to water stress; per capita water availability is one-third of the national average and only half the UN standard for maintaining socioeconomic development.

Wang Lanying, State Office of Comprehensive Agricultural Development

Qun Li, World Bank

Over the past 50 years, the 3H Plain has witnessed a clear trend in climate warming with the mean temperature increasing by 1.18°Celsius. Annual mean rainfall has fallen by 140 millimeters (mm) between 1954 and 2000, with an average annual drop of 2.92 mm, causing more frequent spring droughts, with severe effects on crops.[1] The combination of increasing industrial and domestic water demands and intensifying climate change, which will require farmers to use more water owing to greater evaporation, means that much of the region could face a serious water deficit by 2030.[2]

In 2004, China's government responded by launching a World Bank-financed project that focused on working with farmers and technical experts to implement water-saving measures across the five provinces. The Ministry of Finance's State Office of Comprehensive Agricultural Development (CAD) coordinated activities with assistance from those ministries responsible for water resources, agriculture, land, and forestry. The overall aims were to reverse the inefficient use of water for farming and to increase the financial returns to farmers.

From 2005 to 2010, irrigation-centered engineering, agronomic, and management measures were implemented at a cost of US$463 million across 107 counties. The goal was to improve 505,505 hectares of low- and medium-yielding farmland, benefiting 1.3 million farm families.

The formation of water users' associations, encouraged by the government, provided forums to introduce training in new water management techniques, as well as a mechanism for better local water management based on farmers' participation. Irrigation facilities constructed as part of the project were handed over to these water users' associations so that farmers

It took several growing seasons for many farmers to adopt the new crop varieties, but their reluctance…was eventually overcome by the higher yields delivered.

could begin managing and maintaining the infrastructure. Because in some parts of the region more than 70 percent of farm workers are women, a gender trust fund was used to conduct various training programs in innovative farm practices for women and also for project management officers and experts at each level. This fund also supported initiatives to improve women's participation and capacity in the implementation and management of the water users' association, and the other project activities. Local activities were coordinated through CAD's offices at the provincial, municipal, and county levels, with farmers as the lead players.

Since the project's design did not systematically integrate the risks posed by climate change into all its activities, in 2006 CAD requested, and received, a grant from the Global Environment Facility (GEF) to incorporate adaptation activities into the ongoing World Bank-supported irrigation and agricultural program[3] under the project. This was the first time that climate change adaptation had been introduced into an ongoing Bank-financed project. In addition to water resources advisers, agricultural experts were sent to the area to introduce new drought- and pest-resistant wheat varieties more closely matched to expected future growing conditions. It took several growing seasons for many farmers to adopt the new crop varieties, but their reluctance to shed their decades-long reliance on what one villager called "the same old wheat" was eventually overcome by the higher yields delivered by the new varieties. Similarly, government-led pilot programs introducing new techniques to better manage irrigation water took hold after the farmers saw the benefits for themselves in less wasted water, cheaper irrigation, and reduced groundwater depletion, all resulting in greater water productivity.

One rural area, Xinyi, constructed 17 new sluices, storing 850,000 more cubic feet of irrigation water each year. When combined with other water-saving measures, the water production rate rose from 1.14 to 1.5 kilograms per cubic meter. The changes have also increased the region's capacity to resist extreme weather events. In February 2009, a once-in-fifty-years winter drought occurred in Huaiyuan County of Anhui Province. But thanks to well-established irrigation facilities, better water management, and improved varieties, the wheat seedlings were preserved, and no crops were damaged by the drought.

Through awareness raising, capacity building, and demonstration of adaptation measures, the GEF project over the past four years has increased adaptive capacity in agricultural production in the 3H Plain, becoming an example of the more widespread use of adaptation measures in Chinese agriculture.

LESSONS LEARNED

CAD's role in coordinating actions by the finance, water resources, agriculture, forestry, and land resources sectors was critical to the smooth implementation of adaptation measures across such a large area. As a program that addresses agricultural, rural, and farmers' issues, CAD has a unique advantage in leading China's climate change adaptation activities, including a well-established institutional design, a good reputation among farmers, a strong ongoing investment program that combines both infrastructure and software development, and many years of experience with World Bank-financed projects. This in turn enabled the relatively easy integration of climate adaptation initiatives into the ongoing agricultural improvement project.

Also critical to the project's success was the cooperation and creation of joint ownership with farmers, as well as the partnership with leading scientific and agricultural research institutions for technical support. Besides facilitating water users' associations, CAD sent questionnaires to farmers to elicit their views and suggestions on adaptation measures to ensure that those taken were both technically sound and supported by the farm population. To address the lack of awareness of climate change, CAD also recruited experts from the Department of Climate Change of the National Development and Reform Commission, the China Clean Development Mechanism (CDM) Fund Management Center, the Chinese Academy of Sciences, and the Chinese Academy of Agricultural Sciences to provide information to farmers.

To better improve climate change adaptation in the field of irrigated agriculture, the CAD program should continue to explore new technologies and measures to further improve water efficiency and agriculture based on the lessons learned. In addition, government departments need to be better integrated at the technical level if adaptation approaches are to be used more widely in agriculture development.

Finally, since climate impacts will continue to occur, adaptation measures must be continuously monitored and improved in line with conditions on the ground.

ENDNOTES

1 Tianzhan 2006.
2 Mo 2010.
3 Chinese Academy of Sciences 2007.

CHAPTER 6

TOOLS FOR PLANNING AND POLICYMAKING

IN ADDRESSING CLIMATE RISKS, GOVERNMENT OFFICIALS CAN EMPLOY a wide variety of tools[1] to help them assess current and future types of climate change and the vulnerability of affected populations, ecosystems, or sectors. They can also use tools to inform and prioritize policy options that promote climate-resilient development and that help implement, monitor, and evaluate their decisions.

Examples of these tools are maps, modeling, scenario-planning and simulation exercises, and predictive tools that forecast likely changes as a result of climatic shifts. Taking advantage of these and other tools will not always require expensive new instruments beyond the reach of resource-constrained governments. Often public officials will be able to use generic decision support tools already commonly employed by customizing them for a changing climate. However, it is important to note that all of these tools depend on good information (see Chapter 4).

IMPORTANCE OF TOOLS FOR PLANNING AND POLICYMAKING IN A CHANGING CLIMATE

As decision makers weigh how to respond to different types of climate change within the limits of available resources, they must set priorities and put policies and plans in motion. The choices they make can have significant implications for communities and ecosystems vulnerable to climate impacts and for upfront and future costs. Yet officials often face complex decisions when exploring which actions to take at a national, sectoral, or local level. This is especially true when there is uncertainty over the pace, scale, and scope of climate-related changes. For example, when designing new coastal bridges or coastal defenses like seawalls, planners will routinely face such choices as whether to anticipate sea level rise of 1 or 1.5 meters. Making the wrong decision can be costly.

TOOLS FOR EFFECTIVE DECISION MAKING

There are many tools that can inform and support national and sectoral adaptation planning and policymaking. This report does not systematically evaluate all such tools. Instead, we draw upon our case studies, expert papers, simulation exercises, and research activities to provide guidance on how to use tools to increase the resilience of people and ecosystems. We then highlight several tools that were particularly helpful to decision makers in developing countries and that could be of use to other

R AND KING

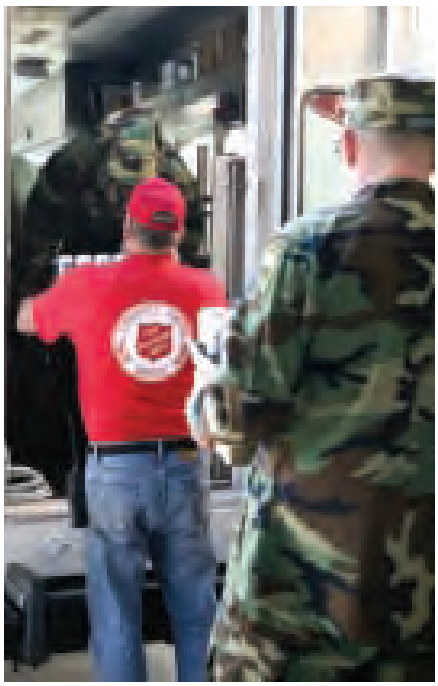
Tools for Planning and Policymaking: In Brief

Tools play a vital role in climate adaptation decision making, including assessing risks and vulnerability and deciding among policy options.

Existing tools can often be customized to serve adaptation planning and policymaking purposes, by integrating climate risks and vulnerability into their use.

Tools for analyzing risks and vulnerability—such as customized maps and vulnerability assessments—can help decision makers identify priority areas for action.

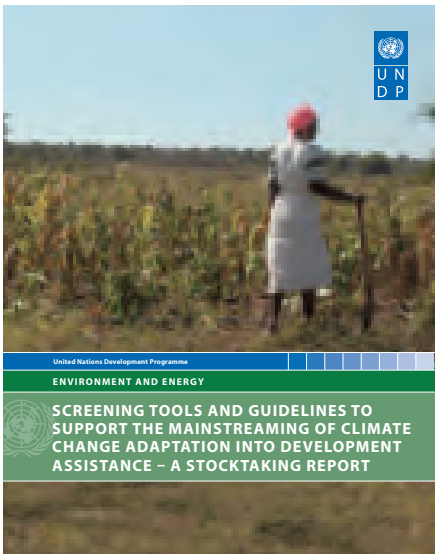
Tools for informing choice of policy options—such as decision route maps, predictive instruments, and scenario-planning and simulation exercises—show special promise for robust and proactive decision making.



governments. Figure 6.1 gives examples of tools with application to adaptation decision making; those discussed in detail in this chapter are underlined.

Integrating Climate Risks and Vulnerability into Existing Tools

In the daily business of government, decision makers already use a variety of tools to assess the consequences of actions and to prioritize activities. An important first step for adaptation planning and policymaking is to integrate climate risks and vulnerability into these existing tools. For example, many countries require environmental assessments before implementing programs or approving projects with potentially significant environmental impacts in order to evaluate possible consequences to ecosystems and communities. These assessments could be strengthened by requiring additional consideration of potential climate risks and associated vulnerability of populations and ecosystems. South Africa has successfully pioneered such an approach. Government mapping of climate risks posed to ecosystems has been integrated into environmental impact assessments of proposed land-planning activities.[2] As a result, local planners have been steered away from activities that would increase the vulnerability of ecosystems to climate change.



For example, planners would avoid development in corridors that could be needed for species migration as temperatures rise.

Economic analyses, and particularly cost-benefit analyses, can also be adapted to better incorporate damages associated with climate change. Economic assessments will play an increasingly important role in decision making for adaptation, given the potential costs involved.[3] To be most effective in supporting decision making, such assessments should be designed to better reflect the opportunities and co-benefits, as well as the costs involved in addressing such changes. For example, the estimated costs should include those actions whose monetary value is difficult to calculate but that are of great importance to human society, such as the decline of local cultures or losses of ecosystem services and plant and animal species. Economic assessments that integrate climate change risks also should take into account the extended time horizons in order to more accurately reflect the long-term risks posed by climate change; this may require adjustments to discount rates.

Often, however, costs and benefits alone will not give government officials the full picture they need to make equitable and effective decisions. In Namibia and Tanzania, for example, economic analyses concluded that climate change could impact GDP by less than 1 percent, but equity and distributional analyses revealed that the burdens of those impacts would fall heavily on smallholder farmers and the urban poor.[4]

The donor community and NGOs have developed numerous adaptation-specific tools and guidelines for use by developing countries. Some provide basic guidance to officials, some are computer-based tools, and others are knowledge-sharing platforms. The World Resources Institute has put forward a National Adaptive Capacity Framework,[5] which policymakers and donors can use as a diagnostic tool of the capacities required for adaptation planning (see p. 74). The United Nations Development Programme (UNDP) has performed an extensive comparative assessment in its publication "Screening Tools and Guidelines to Support the Mainstreaming of Climate Change Adaptation into Development Assistance—A Stocktaking Report." Rather than systematically evaluate and compare these and other tools here, we describe below two important and novel ways in which tools are helping public officials contend with climate risks to assist the most vulnerable populations by:

- analyzing climate risks and vulnerable populations; and
- assisting in choosing among policy options.

Analyzing Climate Risks and Vulnerable Populations

CUSTOMIZED MAPS

Maps are a prominent and easily understood tool that can be used to identify both climate risks and those populations and ecosystems most vulnerable to specific climate impacts. Creating maps from spatially explicit data that record where and how climate-related changes are taking place within a country or region can help in setting priorities and contending with types of climate change ranging from short-term extreme events to long-term change. Such exercises can take place on either a national or local scale and include activities such as hazard mapping and vulnerability mapping.

In helping governments prepare for extreme events, hazard and vulnerability maps can be simple, powerful vehicles to convey risks to populations and infrastructure.[6] The information they

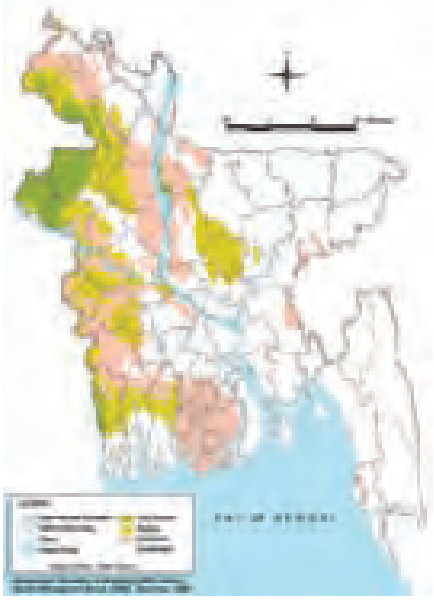
Figure 6.1 Examples of Tools for Planning and Policymaking in a Changing Climate

Integrating climate risks and vulnerability into existing tools	Tools for analyzing climate risks and vulnerable populations	Tools for assistance in choosing among policy options
• Environmental assessments	• Customized maps	• Decision route maps
• Economic analyses	• Integrated assessment models	• Predictive tools
	• Vulnerability assessments	• Scenario planning
	• Impact models	• Multi-criteria analysis
	• Economic models	

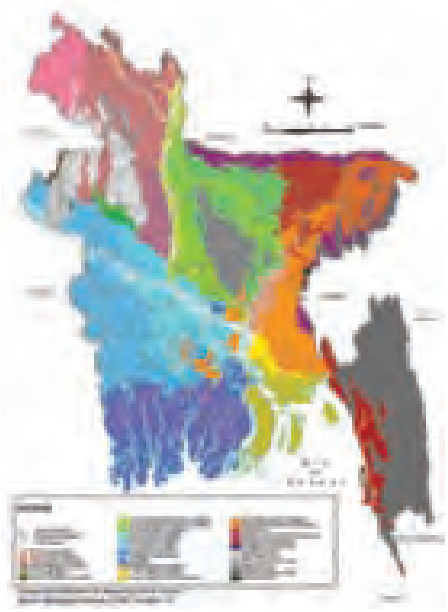
Figure 6.2 The Use of Hazard Maps in Bangladesh

Areas Affected by Cyclones in Bangladesh

Areas Affected by Droughts in Bangladesh



Physiography of Bangladesh



Source: Disaster Management Bureau, Government of Bangladesh.

provide can direct the prioritization of various investments such as evacuation planning and the development and deployment of early warning systems.[7] Some developing countries have produced hazard maps that have proved successful in directing risk reduction efforts.

For example, over the past decade Bangladesh's Comprehensive Disaster Management Programme has developed maps of the risks posed by earthquakes, tsunamis, and storm surges to the country's coastal communities and major cities (see Figure 6.2). To help limit the human, economic, and ecological consequences of such events, these maps have been used in a variety of policymaking arenas, including land use planning, disaster response procedures, and the development of early warning systems.[8] Together with related initiatives, the maps have significantly increased Bangladesh's capacity to respond proactively to disasters. Many lives have been saved as a result. In 2007, when Cyclone Sidr, a category 4 cyclone, struck Bangladesh, early warning systems and evacuations, as well as earlier education campaigns to raise public awareness of the government's disaster plans, kept the death toll to less than 4,000. A previous category 4 cyclone in 1991 resulted in the loss of an estimated 140,000 lives.

Hazard mapping alone, however, is only a first step in protecting the most vulnerable. Data-gathering priorities should also include information on the vulnerability of people and assets in affected areas, which can be overlaid with hazard maps to set priorities and actions.[9] A good example of this, done for conflict prevention, is the Sudan Crisis and Recovery Mapping and Analysis Project.[10] In this case, different data sets and information were overlaid in a GIS system, which makes overlapping trends apparent, helping resolve the conflicts.

Unfortunately, across the developing world and especially in the most vulnerable countries and communities, the underlying data necessary to construct such maps are sometimes missing.[11] In many cases, data scarcity is due to a lack of comprehensive monitoring systems and an associated skilled workforce to analyze, maintain, and provide the data to users in relevant formats. For example, the UK has four times the number of river flow stations as does Malawi, and the data available in Malawi cover fewer years and are of poorer quality. Development is not the only determinant of data availability, however.[12] Malawi's data are of better quality than those of Mozambique, a nation with a similar level of per capita economic development, as Mozambique's records were lost during a period of political unrest.[13]

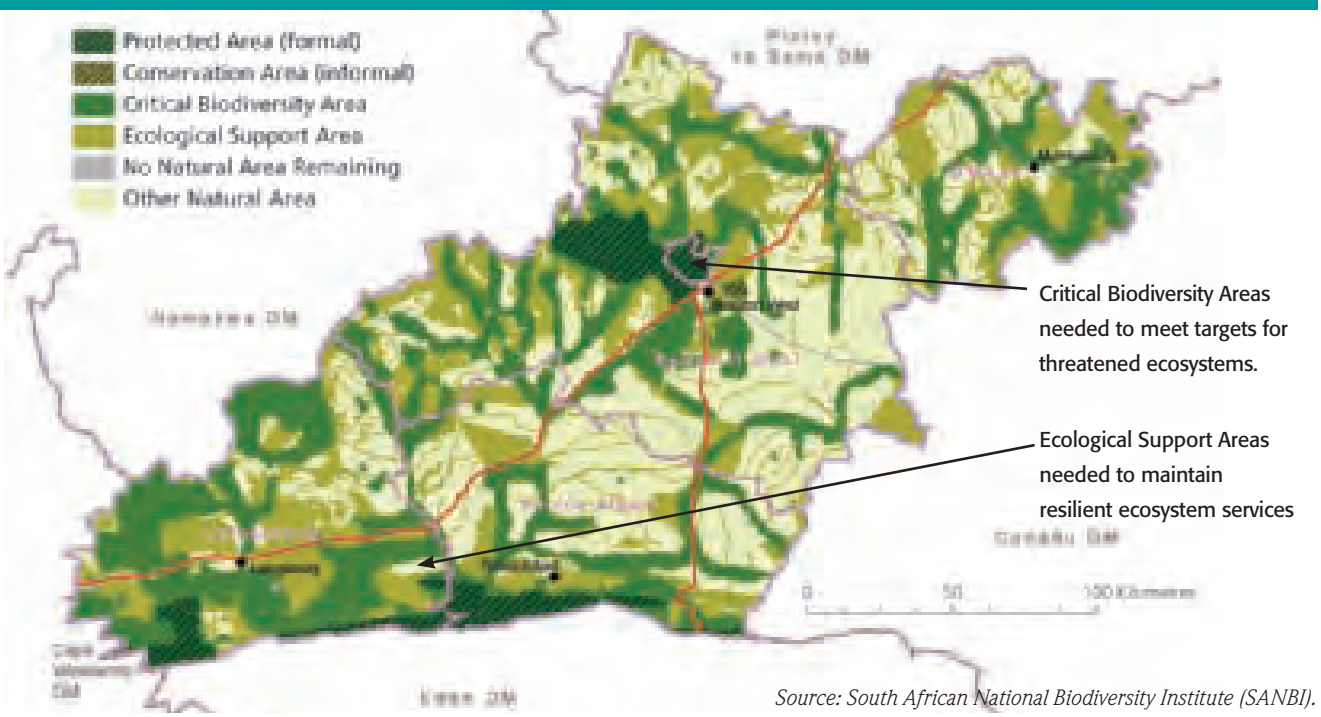
As the importance of data collection for adaptation becomes increasingly critical, donors assisting in the creation of hazard maps need to consider and help address the range of factors that can

WRR EXPERT PAPER

PAUL SIEGEL: "Spatially enabled government uses place as the means of organizing information and activities. New technologies such as Google Earth provide user-friendly information in a very accessible way. Spatial data can be merged with economic, social and environmental data, and information on hazards and vulnerability. This unleashes the power of ICT for a wide range of uses including... land use planning and natural resource management, environmental monitoring and conservation, infrastructure planning... and all phases of disaster risk management, climate change adaptation and social protection."

—Paul Siegel, World Bank consultant

Figure 6.3 Critical Biodiversity Areas and Ecosystem Support Areas in South Africa



Source: South African National Biodiversity Institute (SANBI).

lead to data scarcity. Sustained investments in this area are of vital importance since future decision makers will depend on data collection efforts today to take effective action as climate impacts intensify in the future.

Even when data availability is poor, however, there are some additional or alternative measures that governments can take to develop hazard maps. Gaps in knowledge can be roughly filled in with the use of global or regional information and enhanced by participatory data collection surveys.[14] For instance, the World Meteorological Organization collects data from 18 satellites and shares this information daily with its 187 member countries.[15] There are also global services that help assemble hazard maps, like the Disaster Risk Reduction Programme of the World Meteorological Organization.[16]

Hazard maps are typically created with the use of computer-generated models. While capacity to run such models[17] may not exist in some developing countries, information and communication technologies, such as Geographical Information Systems (GIS) and remote sensing, have greatly improved the ability to assess risks posed by various climate change impacts, such as the increased frequency or intensity of floods and cyclones, glacial melt, and droughts.[18] While the usefulness of such models depends on the available data, many countries have gained the capacity, with donor assistance, to deploy these technologies; in addition, data are increasingly available on the Internet.[19]

In lieu of, or in addition to, GIS and remote sensing, community-mapping exercises are another useful way to gather the information needed to generate maps.[20] For example, communities can undertake visual surveys of areas at risk from landslides, or identify locations that typically flood first in very heavy rains. Such community-mapping exercises can take advantage of local, personal knowledge of climate-related impacts (also see Chapter 4 on gathering local information).[21] Community mapping can also play a vital role in identifying vulnerable groups that need to be targeted in adaptation efforts but may all too easily be overlooked.

As discussed in Chapter 3, it will be critical for communities to understand the importance and relevance of such efforts to their future if their engagement is to be meaningful and long-lasting. When using maps for adaptation decision making, decision makers should therefore ensure that they are presented in accessible fashion to all those involved in, or affected by, their decisions.[22] This may require, for example, translating text into local languages and holding public meetings to explain the purpose of the maps and how they were created.

Maps are useful not only for responding to and preparing for extreme events. They have also been used in planning for long-term changes in the climate. For example, in South Africa, home to three global biodiversity hot spots and around 15 percent of the world's known coastal and marine species, maps are being deployed in efforts to inform and improve how valuable ecosystems, and the services they provide local populations, are managed in the face of climate risks. Specifically, maps have been used both to document low-value land, where conversion for development is more acceptable, and to identify those areas critical to biodiversity conservation, where destructive activities should be avoided. South Africa's government has used such biodiversity mapping not only to inform effective spatial and development planning, but also to create a national strategy to expand protected areas to conserve biodiversity and promote ecosystem resilience. To date, local authorities are using biodiversity-sector plans in seven of the country's nine provinces (see Case Study p. 116).[23]

VULNERABILITY ASSESSMENTS

As described in Chapter 2, the impacts of climate change are influenced by local social, economic, ecological, and other circumstances. that are drivers of vulnerability. Whatever the impact—whether drought, flood, pest infestation, or glacial melt—some people and ecosystems will be more vulnerable than others. Vulnerability assessments profile those most vulnerable to a given climate change by analyzing those factors that will cause certain people and ecosystems to experience such changes differently. We cannot present a comprehensive evaluation of existing approaches here, because there is as yet no one accepted way of undertaking a vulnerability assessment. Among existing approaches, qualitative assessments—which often rely on survey and stakeholder consultations—focus more on processes, conditions, and structures that exacerbate or address vulnerability. Quantitative assessments—which often rely on modeling—might use indicators such as national economic capacity and environmental resources to evaluate an area's vulnerability.[24]

Although this is not an exhaustive list and the factors that need to be accounted for will vary based on location and impact, key inputs into vulnerability assessments include poverty, inequality, health, gender, access to resources, and social status.[25] To be most accurate and useful, vulnerability assessments should rely heavily on engagement with affected communities and groups. This will enable public officials both to identify the chief concerns of those affected and to draw upon local knowledge in planning adaptation and risk prevention measures.[26]

Assisting in Choosing Among Policy Options

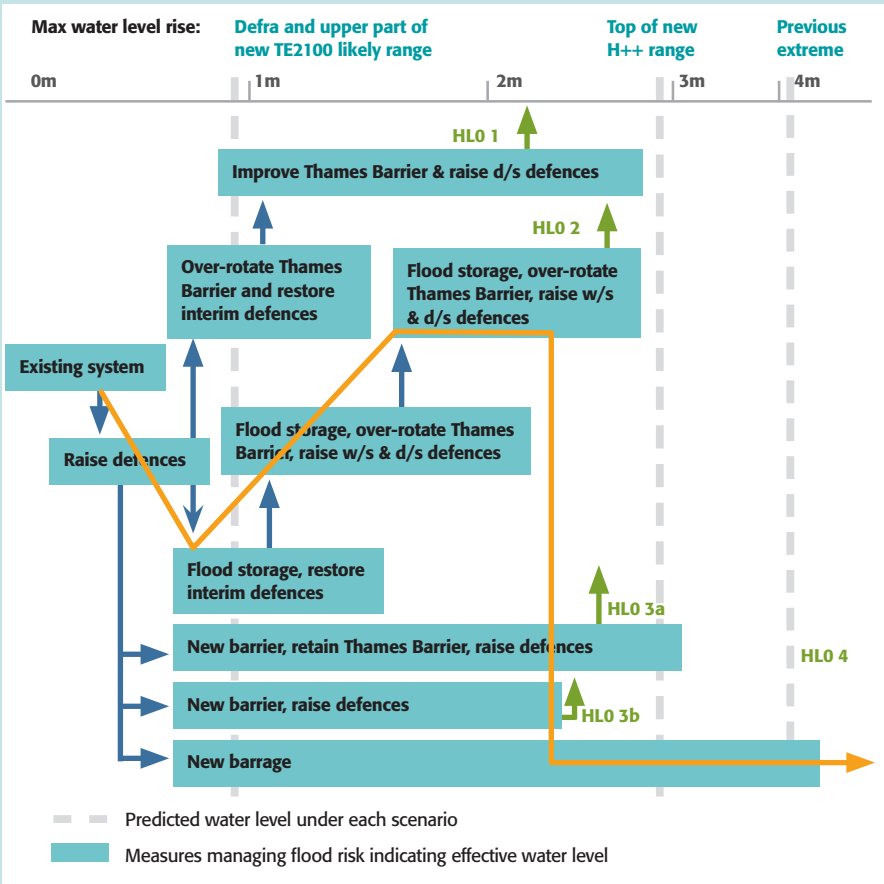
Tools are not only helpful in gathering and analyzing information to identify climate change-related risks. Decision makers can also deploy them to prioritize and choose among policy and planning options. This section describes three tools—decision route maps, predictive tools, and scenario-planning exercises—that have emerged from our research as promising approaches with significant potential for use in the developing world.

DECISION ROUTE MAPS

One way that governments can address long-term climate change, given competing short-term priorities and scant resources, is to take "low regrets" actions today that can be expanded or altered in the future if conditions warrant. Decision route maps provide a useful aid as planners look to take incremental short-term action that does not foreclose the option of taking more aggressive action later. This tool is particularly useful for contending with long-term uncertainty and advancing robust adaptation strategies over years or decades. It works by identifying different options for policymakers depending on how climate impacts unfold.

As Chapter 4 described, the Thames 2100 project in the UK identifies adaptation measures that can be sequenced over time if the risk of flooding in London increases due to sea level rise. Box 6.1 shows five increasingly aggressive options, ranging from improving the existing Thames barrier to building a new barrier if sea level rise increases past a certain indicator point. The decision route map builds in estimates of the time needed to switch interventions so that no option is ever taken off the table because of time constraints. The decision route map is also

Box 6.1 The Use of Decision Route Maps in Thames River Planning, UK



High-level adaptation options and pathways developed by TE2100 (on the y-axis) shown relative to threshold levels increase in extreme water level (on the x-axis). The orange line illustrates a possible 'route' where a decision maker would initially follow HLO 2 then switch to HLO 4 if sea level was found to increase faster than predicted.

This decision route map shows a range of potential actions to respond to various scenarios of sea level rise affecting the Thames River Barrier, designed to keep London from being flooded. The map should be read from left to right. Options to the left are designed to deal with relatively low sea level rise. If it becomes apparent that sea level rise is greater than that particular option can withstand, it is no longer viable. Boxes to the right are viable in responding to a greater rise in sea level, but also may require more aggressive action and be more costly. Those interventions that have a longer line can withstand more flood risk. The long diagonal arrow is an example of a chosen decision route.

— Adapted from Tim Reeder and Nicola Ranger, WRR Expert Paper

scenario neutral (see Box 6.3) and does not require calculation of the probabilities of various impacts, thus making the tool much less data intensive and costly.

This tool is effective when decision makers have specific information: the range of thresholds (such as increments of sea level rise) when certain responses would be triggered, with sufficient time for implementation of each (see Chapter 4).

PREDICTIVE TOOLS

Early forecasting of coming change, such as altered rainfall patterns or predicted outbreaks of pests, can also inform effective action and lead to proactive decision making. Tools that provide information about expected shifts in the climate or seasonal weather patterns can enhance decision makers' ability to take action early before it becomes too late to act effectively.

One such example is an online predictive tool used for managing destructive peatland fires in the Indonesian province of Central Kalimantan. These fires have claimed lives and property while releasing high levels of greenhouse gas emissions (see Indonesia Case Study p. 67). The International Research Institute for Climate and Society (IRI) of Columbia University's Earth Institute, and Bogor Agricultural University, in collaboration with Indonesia's government and non-governmental organizations, created the innovative forecasting tool in 2007. The computer-based tool makes predictions based on province-wide seasonal weather forecasts updated on a monthly basis, and district-level rainfall data updated every week and a half. The rainfall data collected are used to compare historical records with new patterns of change. This tool has been successfully deployed by provincial authorities, allowing for earlier predictions—up to two months—of fire activity. The result has been better management of controlled burning for land clearance by smaller farmers and plantations.[27]

Box 6.2 Ghana and Vietnam Climate Adaptation Simulation Exercises

The *World Resources Report* partnered with the U.S.-based Consensus Building Institute to run two in-country adaptation simulation exercises, in the electricity sector in Ghana and the agriculture sector in Vietnam. The purpose was to learn how officials make decisions when confronted with climate-related policy choices that pose significant future consequences.

Ghana Simulation

The participants in Ghana focused on assessing climate risks and related uncertainties regarding decisions about energy infrastructure investments in imaginary Suna, a French-speaking country in West Africa. Suna faces rural poverty and high levels of unemployment, but foreign direct investment-led industrialization has brought decent jobs to urban areas and a revenue stream for the government. A major river runs from northeast to southwest, with its delta in Suna's capital city. Since the 1950s, dams on the river have provided a stable supply of cheap electricity, meeting industrial and urban needs. A proposed large new dam is slated to help Suna meet its energy needs in the medium term, providing 425 megawatts of installed capacity to meet growing demand. The dam is being made possible by a loan of US$350 million, to be paid back over 35 years, and will have an operating life of approximately 70 years.

However, scientists at Suna National University recently published a study showing that predicted rainfall and temperature changes could significantly threaten the dam's future capacity to generate electricity. In the simulation, the participants role-played high-level decision makers and representatives from civil society organizations and the private sector. They were charged with determining whether (a) the dam should proceed as planned, (b) the project should be re-evaluated, or (c) the dam should be abandoned. After the simulation, participants joined a debriefing led by WRI and the Consensus Building Institute that connected the simulation exercise to the real situation in Ghana.

For a full description of the exercise, please visit *www.worldresourcesreport.org/country-scenarios*.

Ghana Results

The participants chose to go ahead and build the dam. There was broad agreement that short-term energy needs trumped any other considerations. The outcome suggests that if developing country governments are to take long-term climate adaptation measures, it will be necessary to demonstrate clearly that social and economic co-benefits will result.

The exercise demonstrated that governments and other stakeholders discounted long-term risks several decades into the future. Some of the participants dismissed the university's research, for example, as simply "yet another study." This suggests that a key challenge for donors and others will be to create incentives for developing countries to integrate climate risks into national planning and policymaking, so that it is seen as an opportunity and not merely another claim on scarce resources.

Interestingly, the participants did support additional steps to contend with some risks while proceeding with the dam. For example, they supported planting forests in the surrounding areas and adopting changes to water management schemes to increase flow and help maintain the supply of water for the hydroelectric dam. These were "low regrets" options that reduced climate impacts within the parameters of their chosen decision.

Vietnam Simulation

The participants in this exercise examined key dilemmas that governments in countries like Vietnam are likely to face, given the predicted sea level rise. In the context of Vietnam's Mekong Delta, these dilemmas include trade-offs between short-term and long-term adaptation needs and strategies, difficult decisions about protecting or abandoning highly vulnerable coastal areas, and the need to protect food security while supporting job creation in other sectors such as industry.

The simulation describes a fictional country called Rinsap, which resembles Vietnam, which is being offered US$500 million in foreign aid to assist its delta region to become better prepared and more resilient in the face of climate change. In order to receive the funds, the prime minister's office must consult government authorities, scientists, and farmers about the best use of the resources. The day-long simulation involved a meeting of eight key stakeholders, in which they were asked to make a recommendation to the prime minister, who was looking for near-consensus agreement on a package of priorities. The participants weighed the options, including investments in protective infrastructure; mangrove restoration; new agricultural technologies and techniques; and diversification of rural livelihoods, including relocation. In exploring these trade-offs, participants discussed the pressing issues for the country's future, such as food security, farmers' incomes, and job growth in the face of land inundation. Each participant had confidential instructions that described that particular stakeholder's priorities and core interests.

In a debriefing after the simulation, led by WRI and the Consensus Building Institute, the participants discussed how well the simulation reflected Vietnam's realities and the real-world decision-making process of incorporating climate risks. For a full description of the exercise, please visit *www.worldresourcesreport.org/country-scenarios*.

Vietnam Results

All the groups chose to prioritize proactive protective measures, including built infrastructure (dikes) and "green infrastructure" (mangroves). Protection of agriculture, food security, high-value food production, and current livelihoods were taken as givens. Measures that significantly altered current economic activities, such as diversification of livelihoods, and more drastic measures to move vulnerable populations to less exposed land were at the bottom of the list.

Box 6.2 Ghana and Vietnam Climate Adaptation Simulation Exercises (continued)

Vietnam Results (continued)

The exercise demonstrated that the most appealing interventions for all constituencies were those that promoted continued existing livelihoods and protection of existing assets. Any consideration of more aggressive action that would require different incentives, resources, and decision-making processes was less appealing. The exercise underscored the great influence of traditions in Vietnam, including the importance of rural life and long-held family land. This suggests that it will take time for officials making decisions for a changing climate to absorb the reality of having to accept some losses, and even longer to become comfortable entertaining alternatives (such as the relocation of rural communities) that will disrupt entrenched patterns of society.

SCENARIO PLANNING AND SIMULATION EXERCISES

From private corporations to the military, a host of institutions use scenario planning as a way to prepare for different possible futures. Scenarios provide alternative views of the future against which plans and policies can be tested. Given the many types of change and uncertainties associated with rising global temperatures—from extreme weather events to changing seasons to long-term sea level rise—scenario planning can also play a valuable role in adaptation planning and policymaking.

The *World Resources Report* amended traditional scenario planning to a simplified simulation exercise. It ran two such simulation exercises during its research phase, designed to generate discussion about planning for future change. The exercises took place in Ghana and Vietnam in late 2010 and involved public officials from the countries' energy and agriculture ministries, academics, and civil society representatives. Box 6.2 describes the exercises and their outcomes.

From a national policy maker's perspective, such exercises have several advantages. Their use can facilitate exchange among stakeholders whose support will be needed to undertake effective adaptation measures, bringing together public officials with academics, NGOs, and community representatives, as well as enhancing public engagement in decision-making processes. Such gatherings can also highlight key challenges involved in balancing the science of climate impacts with the interests of various stakeholders. These exercises, as well, can clarify the resources and conditions required, and the trade-offs involved, for countries to prepare effectively for future change. Role playing also allows decision makers to step away from entrenched stances and positions, forcing a fresh look at problems. Reviews of the exercises, usually held after the role-playing simulations are completed, allow officials and other stakeholders taking part to connect the lessons learned with the real-world problems they face.

The strategies suggested in this and the preceding three chapters all rely on one vital additional ingredient: resources. It will take considerable financial, human, and social capital for developing country governments to pursue a comprehensive approach to make their economies and communities climate resilient. In addition, the success of many of the strategies we suggest will depend on maintaining the ecological resources on which all, especially rural, communities depend. The next chapter explores resource needs and approaches for public officials to consider in responding to and preparing for a changing climate.

Box 6.3 Scenario-Neutral Approaches

A scenario-neutral approach looks at an uncertain situation, analyzes which types of change would result in increased vulnerability, and then takes steps to design an aggressive course of action in response. Robert Lempert and Nidhi Kalra of RAND give an example by imagining the application of this approach by a civil engineering team in a developing country:

"The engineers would begin with the current design for their road, that is, the design that does not consider any future change in flood frequency or other effects of climate change. The team would then specify the performance objectives their road aimed to achieve. They would then ask the question, 'What future combinations of flood frequency, other climate conditions (e.g. temperature extremes, precipitation), land use patterns, and traffic demands would cause the road to fail to meet those performance objectives?' The team would interpret these sets of future conditions as scenarios that represent vulnerabilities of the current road design. Note that this step of the analysis relies far more on information the engineers are likely to possess—how their road would perform under a variety of future conditions—rather than information they may lack—patterns of future climate and economic growth in their region.

The engineers can then identify how they might modify their plans for the road to address each of the vulnerable scenarios. Perhaps they might add more drainage or adjust its route. Perhaps they can identify low-cost measures they could take in the near-term that might improve the ability of the road's future managers to make adjustments in response to particular climate changes, for instance ensuring space is available to add additional drainage in the future. This step of the analysis—identifying potential modifications to their initial plan—also relies on information the engineers are likely to possess about alternative road designs, rather than on information they may lack about future climate and socio-economic conditions."

— Robert Lempert and Nidhi Kalra, WRR Expert Paper

CASE STUDY

BANGLADESH: Disaster Management in a Changing Climate

BANGLADESH IS ONE OF THE WORLD'S MOST NATURAL DISASTER–PRONE NATIONS. IN A TYPICAL year, about 10 million of its citizens are affected by one or more climate-related hazards, and a quarter of the country is inundated.[1]

Kirsten Luxbacher, Independent Consultant

Abu Mostafa Kamal Uddin, United Nations Development Programme

In the 1990s, two factors changed Bangladesh's approach to disaster planning. An earlier program was deemed unsuccessful after it did little to improve the preparedness for and response to a major cyclone in 1998. At the same time, it became more evident that the natural disasters to which Bangladesh is prone would only become more frequent and more severe with climate change. The result of that change in attitude was Bangladesh's Comprehensive Disaster Management Programme (CDMP), probably the most ambitious of its kind in a developing country.

The CDMP has two goals: to facilitate a paradigm shift in disaster management in Bangladesh away from relief and rehabilitation toward risk reduction and to foster a holistic, multi-hazard approach to reducing the nation's risks and vulnerabilities.[2]

The program's first five-year phase, which ended in 2009, has had several notable outcomes, including the creation of the Disaster Management Information Centre; the systematic and sophisticated mapping of hazards, risks, and vulnerabilities; and a comprehensive training program for public officials.

Taken together, these initiatives have significantly increased the nation's capacity to respond proactively to disasters and have saved many lives. This was illustrated most dramatically by the successful large-scale evacuations that preceded Cyclone Sidr in 2007. Effective early warning systems, preceded by public awareness campaigns, kept the death toll at fewer than 4,000, compared with the loss of an estimated 140,000 lives when a cyclone of similar force hit the country in 1991.

This flagship program could serve as an example for other nations.

While some hurdles remain, the government of Bangladesh and its implementing partners—the United Nations Development Programme (UNDP), the United Kingdom's Department for International Development (DFID), the United Nations Office for Project Services (UNOPS),

and the European Union (EU)—have created a flagship program that could serve as an example for other nations. Phase II, implementation, is fully funded by Phase I and new donors, and is now under way. Many of the CDMP's components are discussed next.

Disaster Management Information Centre

In the aftermath of an extreme event, planning agencies must be able to react quickly. Accordingly, the CDMP established the Disaster Management Information Centre, which rapidly collects and distributes information whenever major flooding, cyclones, tsunamis, earthquakes, or other significant weather events occur. It is kept operational 24/7 during emergency situations[3] and is connected via telecommunications links and a web portal with the nation's 64 districts and 235 local administrative (upazila) centers identified as being at high risk for extreme weather events. The Disaster Management Information Centre also provides information technology (IT) support to two government agencies, the Meteorological Department and the Flood Forecasting and Warning Centre.

Climate Change Study Cell

The CDMP also established a climate change study cell that has developed climate change impact scenarios for specific regions of Bangladesh. In collaboration with the United Kingdom Met Office's Hadley Centre for Climate Change, this has provided training in regional climate modeling to Bangladeshi government officials and professionals from nongovernmental organizations. A national climate change database and library specializing in climate change and a network of representatives from the relevant ministries and departments also were established.[4]

In a separate capacity-building initiative, since 2007 the CDMP has developed disaster preparedness training manuals and conducted training events for some 25,000 public officials. The government also has engaged universities across the country to develop disaster management curricula.

Hazard, Risk, and Vulnerability Mapping

Hazard maps have been prepared that assess the earthquake risk for three major cities, Dhaka, Chittagong, and Sylhet. Among other details, the maps show fault lines, soil texture, and building design. In addition, there are now hazard maps for the entire coastline of the country detailing the risks of tsunamis and storm surges. City governments have used this information to improve their planning and building codes, to draw up response procedures and early warning systems, and to set priorities for adaptation activities.[5]

Community Risk Assessments

To help local governments prepare for natural disasters, CDMP officials, assisted by local disaster management committees and NGOs, use inclusive, participatory methods to identify and evaluate the hazards, risks, and vulnerabilities that communities face. The aim is to combine scientific data and forecasts with local knowledge to form a well-rounded and accurate assessment, which then becomes the basis of a risk reduction action plan of activities on which the community will concentrate.[6] Such projects often include, for example, crop and agricultural risk reduction activities, training in disaster preparedness, afforestation initiatives, and road elevation.[7]

BANGLADESH: LIVING WITH CLIMATE HAZARDS

The Centre for Research on Epidemiology of Disasters estimates that in Bangladesh from 1979 to 2008, more than 191,415 people were killed and about 229 million were directly affected by natural disasters such as storms, tornadoes, floods, and landslides. The total economic damage was estimated at US$5.6 billion.

The impact of these disasters was exacerbated by the fact that about 40 percent of the nation's population lives below the poverty line and two-thirds of the country is less than five meters above sea level.

Climate change is expected to cause more frequent and severe tropical cyclones, heavier and more erratic rainfall during the monsoon season, melting of Himalayan glaciers, and rising sea levels.[8]

LESSONS LEARNED

High-level support has been critical to the CDMP's success. Not only did the Secretary of the powerful Ministry of Food and Disaster Management assume the position of national project director of the new disaster management program, but other ministers also embraced the need to incorporate disaster risk reduction into their national poverty reduction strategy and development planning. Partnerships with sub-national governments and institutions also were important. Today, more than 75 organizations are part of the network, thus greatly increasing the program's reach beyond its original seven pilot districts.

The fledgling program has not been without challenges, however. The high turnover of CDMP employees, as well as the frequent failure to pay them, has been problematic, and over the first five years there were no fewer than seven Secretaries and five Directors General of the Disaster Management Bureau. In addition, the mainstreaming of disaster risk reduction has been confined primarily to the CDMP's implementing agency, the Ministry of Food and Disaster Management.

The Government of Bangladesh has acknowledged the need to ensure the transparency and accountability of community-level disaster risk reduction initiatives and the inclusion of vulnerable and marginalized groups, such as women and the poorest of the poor.[8]

The government has pledged to address these challenges during the program's second phase, which began in 2010. The principal goal is to institutionalize risk reduction and climate change adaptation across 13 key ministries and agencies. The areas of focus are policy and legal instruments, capacity building for officers at all levels of government, knowledge generation and access, and the creation of institutional linkages.[9]

ENDNOTES

1 Ernst, Government of Bangladesh 2009.
2 Government of Bangladesh and UNDP n.d.; project document n.d.
3 Russell et al. 2009.
4 Russell et al. 2009.
5 Rector 2011.
6 Ministry of Food and Disaster Management Government of Bangladesh n. d.
7 Russell et al. 2009.
8 Government of Bangladesh 2009.
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10 Government of Bangladesh 2010.

CHINA: Controlling Yangtze River Floods

FOR NEARLY A MILLENNIUM, CHINA'S EFFORTS TO CONTROL FREQUENT FLOODS IN THE YANGTZE RIVER basin centered on "hard engineering" measures like dikes and polders, which are artificially created areas designed to either keep out or retain water. But after disastrous flooding devastated the central Yangtze region in 1998, killing more than 4,000 people and inflicting economic losses of US$25 billion, the government adopted a radically different, "soft path" approach.

Jamie Pittock, Australian National University

Ming Xu, Institute of Geographical Sciences and Natural Resources Research, Chinese Academy of Sciences

In the central Yangtze basin, this approach resulted in restoring the natural floodplain over several thousand square kilometers by removing an extensive network of dikes that formed polders for rice production. Around 2.4 million people were relocated from the floodplain to nearby villages on higher land and given state assistance for housing reconstruction, household biogas systems, and the establishment of new agricultural businesses.

The Chinese government considered restoring the floodplains to be a "no regrets" adaptation option because it was a robust way to manage climatic variability and change while also providing extensive environmental and socioeconomic benefits. Not only can larger floods be more safely managed, since the floodplain now holds the overflow, but the environment has benefited as well through improved water quality, recovery of flora and fauna, conservation of threatened species, and designation of nature reserves. Even though the relocations disrupted a large number of people, their livelihoods and resilience arguably improved as a result.

USING NATURE TO ADAPT

The Yangtze is the longest river in China, stretching 6,300 kilometers and draining a basin covering 19 provinces over an area of 1.8 million square kilometers.[1] More than 400 million people live in the basin, which produces 40 percent of China's gross domestic product. In the central Yangtze, poor floodplain communities depend largely on growing rice or aquaculture products, thus making their livelihoods vulnerable to disruption by flooding.

Benefits include enhanced fish stocks, improved water quality, and diversified livelihoods.

In recent decades, local populations and infrastructure were regularly affected by heavy monsoon flooding, which threatened catastrophic damage and loss of life if levee banks were breached. The increased frequency of dangerous flooding was attributed to several causes, including the reclamation of floodplains for agriculture, which forced floodwaters into smaller areas with higher flood peaks.[2] Another factor was greater erosion of the watershed, which silted up the central Yangtze lakes, and of floodplain areas that previously were able to safely hold water from major flooding. In total, from the early 1950s to the late 1990s, more than 3,000 square kilometers of wetlands disappeared in the Yangtze River basin.

In addition, by the late 1990s, China's government and scientific community had become increasingly concerned that climate change was contributing to more frequent extreme weather events in the region.[3] The inclusion of floodplain restoration measures in the 2007 National Climate Change Program reflected this concern.

Following the disastrous 1998 floods, China's government took further action, instituting a comprehensive "32 Character Policy" in an effort to prevent such events in the future from destroying the region. This intervention, designed as a 30-year policy to be implemented in five-year stages, had four major elements:

- Increasing forest coverage by enhancing the protection of forests and planting forests in steep farmlands.
- Restoring floodplains by removing embankments and converting agricultural polders to floodplains to increase the capacity to retain floodwaters.
- Resettling farmers by building new townships and providing them with jobs instead of agricultural subsidies.
- Strengthening levees and dredging riverbeds.

These measures were implemented primarily by the provincial governments and the national Ministry of Water Resources. At the national level, the project was coordinated by the State Council and jointly implemented by sectoral agencies, including the Ministry of Agriculture, the State Forestry Administration, and the Ministry of Environmental Protection (the former Environmental Protection Authority). In some cases, nongovernmental organizations, including the World Wildlife Fund (WWF) partnered with the authorities. For example, the WWF persuaded agencies in several districts to open sluice gates to reconnect floodplain wetlands with the river, resulting in the recovery of both fish stocks and biodiversity.

Across the basin, the program to date has restored 2,900 square kilometers of floodplains, thereby adding a retention capacity of 13 billion square meters.

The extensive environmental benefits are increases in fish stocks and migratory birds, as well as improved water quality. The economic benefits include the diversification of livelihoods from growing rice to raising fruit and vegetables, fish, silkworms, bamboo shoots, lilies, and livestock. In some areas, subsidized biogas plants running on animal manure now provide clean energy and organic fertilizer. The income of several communities relocated to lakes has risen by 30 to 40 percent.[4]

Although the large-scale relocation of communities was controversial, these populations generally lived in poverty from the effects of frequent flooding and were in ill health due to high rates of schistosomiasis in the floodplains. The intervention of the government to move these people to higher ground has enabled them to improve their living conditions, on average, with better health, better housing, access to government-provided services and livelihoods, and reduced flood risk. Not everyone has benefited, however, and some have alleged corruption in the distribution of subsidies and other resources.

LESSONS LEARNED

This policy is an example of a proactive risk management strategy that utilizes China's scientific capacity and cross-sectoral planning mechanisms and is implemented with substantial government investment. An important element of the approach taken by the government is the iterative development and implementation of targeted policies that favor adaptive management.

Given the extensive flood management measures implemented, leadership at the highest level was critical to the program's enactment. Although the program was jointly implemented by relevant sectoral public officials, the authority and oversight provided by China's State Council via the powerful National Development and Reform Commission was a key factor ensuring cooperation among the many government agencies involved.

Barriers remain, however, including the challenge of coordination of overlapping institutions, ongoing advocacy by public officials for hard engineering solutions, and the inability to hold local officials accountable for implementing national policies.

ENDNOTES

1 Yang et al. 2009.
2 Yu et al. 2009.
3 Jiang et al. 2008; Xu et al. 2009.
4 WWF 2003; Yu et al. 2009.

CHAPTER 7

RESOURCE

ADAPTING TO CLIMATE CHANGE IMPACTS WILL REQUIRE A HUGE expenditure of financial and human resources, and the effectiveness of interventions will often depend on ecological and social resources as well. This will impose a substantial burden on many developing countries, the nations least responsible for rising greenhouse gas emissions. Recognizing this, industrialized countries have agreed to a provision in the Copenhagen Accord, negotiated in 2009 through the United Nations Framework Convention on Climate Change (UNFCCC), to mobilize US$100 billion a year by 2020 to address both mitigation and adaptation in developing countries.[1] Climate financing, however, will not cover all adaptation needs, given the likely impacts across society. Hence, as donors increasingly recognize, there is a critical need to integrate climate risks into development aid, investments, and planning. Also, as we describe in this chapter, it will not only be necessary to have more financing, but also different types of financing. In addition, other resources—human, ecological, and social—are needed and will play critical roles in enabling governments to advance effective adaptation processes.

IMPORTANCE OF RESOURCES IN A CHANGING CLIMATE

The effective deployment of financial support will be critical if developing countries, many of which will bear the brunt of predicted climate impacts, are to prepare for extreme events, a more variable climate, and long-term change that may force changes to human habitation, infrastructure, and the make-up of their economies. In addition, human resources (such as trained engineers, data-processing technicians, and scientists) and ecological resources (which provide services such as food, freshwater, and erosion control) will also be critical if developing countries are to become more climate resilient. Social resources will enable communities to coordinate and cooperate in addressing and coping with adverse conditions.

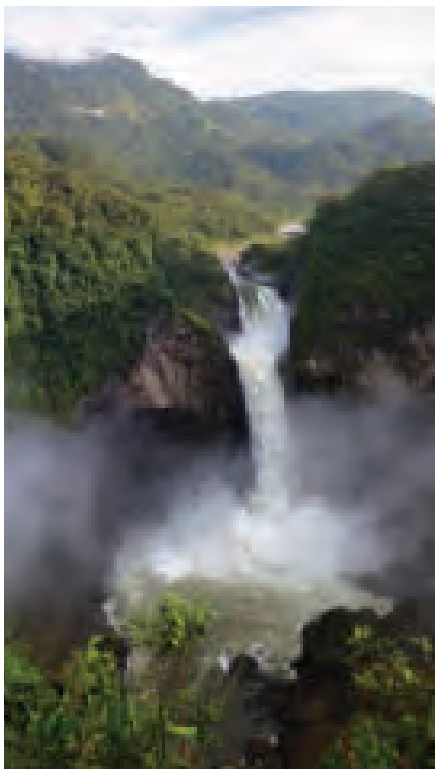
Some resources are direct inputs into policy and planning processes. Examples would include funding for specific activities such as mitigating the impact of droughts or developing coastal zone management plans. Others can be described as background conditions. For example, healthy mangroves and wetlands can provide significant benefits in the form of buffering and absorption in the face of

storm surges, while the absence of such healthy ecosystems increases the likelihood of damaging impacts. Similarly, social resources can create the background conditions for more effective adoption of adaptation efforts on the ground, as we describe below.

In the face of extreme events, effective early warning systems, disaster response education, and enhanced capabilities to deploy resources all require human resources in the form of technical capacity. Financial resources are also paramount to deal with the aftermath of events that can overwhelm the capacity of a country to respond. The floods that engulfed a third of Pakistan in 2010, for example, affecting 20 million people, required US$2 billion just for relief and early recovery assistance. Several billion dollars more will be needed to rebuild the flood zone, an area the size of England.[2] Social and ecological resources will be a major determinant of communities' abilities to adapt on their own.

Heightened variability will place different demands on resources. For example, monsoon patterns can be altered, seasonal temperature ranges can change, and droughts can stretch from months to years, each of which will have its own resource needs. Governments will need both financial and human resources at their disposal in order to develop and implement flexible plans to cope with variability and to build the capacity to collect and analyze locally relevant seasonal data (see Box 7.1).

Preparing for long-term change will require significant resources to strengthen governments' capacity to assess vulnerabilities and risk, select policy instruments, and implement and enforce durable activities. As global average temperatures continue to rise, donors will need to play an increasingly important role in implementing these activities, while also reinforcing governments' abilities to take action on their own. Efforts will need to be undertaken that empower national stakeholders, strengthen alignment among national government agencies, enhance effectiveness of assistance, foster political leadership, and assist in integration of climate risks into national development planning and across sectors.[3] Donors will need to play an essential role in providing new and additional financial aid and to work with governments to help strengthen human, ecological, and social resources.



Resources: In Brief

Financial

As the impacts of climate change intensify, long-term financial support from governments and donors will be essential to maintain initiatives and infrastructure and ensure that investments pay off. It will be important to move beyond project financing to full integration of climate risks into investments, planning, and policymaking.

Fit-for-purpose financing mechanisms are necessary—providing developing countries with access to both long-term, flexible financial support and credit lines to tap quickly for extreme events, especially those that come as a surprise.

Financing should not focus solely or primarily on built infrastructure but should build the skills and capacities of decision makers and communities, as well as invest in strengthening ecological resources.

Human

Many developing countries lack the human capital to prepare their societies for impending climate impacts and to integrate climate risks into plans and policies.

National governments urgently need to build the knowledge and technical skills of public officials in order to prioritize, design, implement, monitor, and evaluate adaptation initiatives.

Ecological

Climate change is altering the capacity of ecosystems to supply essential services such as freshwater, natural hazard protection, and food. The resulting effects could be significant, especially for rural regions of the developing world.

Ecosystems can help mitigate many natural hazards, such as storms. Maintaining them can be less costly than building expensive infrastructure and can provide co-benefits to society.

Ecosystem-based adaptation efforts rely upon restoring, maintaining, or enhancing healthy ecosystems. Therefore, policymakers need to assess not only how ecosystems can strengthen communities' resilience but also how ecosystems themselves will be affected by a changing climate, and take measures accordingly.

Social

Social resources can build the resilience of vulnerable populations in a number of ways. When allowed to flourish, social resources encourage and support mutually beneficial coordination and cooperation among communities, create opportunities for collective action, provide safety nets in times of crisis, and develop mechanisms to share other forms of capital.

WRR EXPERT PAPER

RICHARD MUYUNGI: "There is still a challenge in comprehending the differences between traditional bilateral support and the negotiated financial commitments under the Climate Change Convention process (such as the green funds under the Copenhagen Accord, the GEF climate change funds or the Adaptation Fund under the Kyoto Protocol) and how such support could be harmonised in support of climate change adaptation in recipient countries. Development agencies should support recipient governments to put in place nationally owned processes and mechanisms that will allow financing harmonisation (including expedited processes for accessing financing) and complementality. Ministries responsible for finance, planning and climate change should lead the process of financial harmonisation taking into account the national budgeting process and guidance."

— Richard Muyungi, Vice President's Office, United Republic of Tanzania
WRR Expert Commentary

RESOURCES FOR EFFECTIVE DECISION MAKING

While financing of adaptation is of central importance, a broader suite of resources will be necessary to bolster adaptation planning and policymaking.[4] In this chapter, we highlight a range of policy approaches and initiatives that have emerged from our research that can strengthen financial, human, ecological, and social resources, in differing combinations, that will be needed in most situations. We believe that these approaches, with donor support and involvement, could be more widely deployed to help make populations and ecosystems more climate resilient.

Financial Resources

Even in the current climate of international austerity, it will be essential for industrialized countries and international donor agencies to honor their financial commitments to both official development assistance (ODA) and climate finance if adaptation activities are to be adequately supported.[5] UNFCCC Parties have repeatedly called for developed countries to provide "new and additional" funds for climate finance, to avoid diverting funding from other pressing objectives.[6] Accreditation processes, access criteria, and delivery procedures for both official and non-official development assistance also need to be adjusted to speed the delivery of adaptation aid.[7]

It will be necessary to continue and improve existing development assistance strategies. For example, in line with the Paris Declaration on Aid Effectiveness and the Accra Agenda,[8] aid efforts should be directed to strengthening human and institutional capacities, improving land rights, enhancing social protection, and ramping up access to services.[9]

But we must also do things differently. Financial needs in a changing climate are not simply about more financing. A different type of financing is also important, one that is fit-for-purpose and responds to the unique challenge of climate change and the variety of impacts it will bring. We will need to go beyond project financing to ensure that climate risks are fully integrated into investments, plans, and policies. Funding mechanisms must provide access to more long-term, flexible support than is standard today, and to enable quick access to secure credit lines that cash-strapped countries can tap quickly in case of extreme events. For these changes to occur,

Plowing a field in Mozambique.

certain hurdles will have to be addressed; they include the non-performance of loans, lack of financial regulatory frameworks, high financing transaction costs, and lack of client country political stability.[10] Financing should target specific needs and the most vulnerable members of society. Next we discuss three types of fit-for-purpose financing for a changing climate: long-term commitments, credit lines and insurance that can be tapped quickly, and a shift away from hard investments.

LONG-TERM FINANCIAL COMMITMENTS

Long-term financial commitments are needed to help societies prepare for climate impacts that will unfold over decades, such as the salinization of farmland due to sea level rise. In addition, domestic and international public finance for risk prevention, relief, and recovery will also be important to minimize the impacts of extreme events. For example, many interventions to contend with floods, cyclones, and other disasters will depend on information collected by weather stations. Comprehensive data on local-level climate conditions in the most vulnerable countries will be available only if the international community supports an exponential expansion of weather stations in Africa, Asia, and Latin America, as described in Chapter 4, and ensures that these and existing stations are maintained over time.

Long-term, committed financial support is vital to the effectiveness of policies and plans over time, since without it, systems often fail. It is also key for donors to have an exit plan that creates local ownership of adaptation activities. This connection was highlighted both positively and negatively in several case studies prepared for this report (also, see example in Box 4.4, in Chapter 4).

In Nepal, the government did not secure the funds to operate and maintain the early warning system it built to alert remote mountain communities in the event of a glacial lake outburst flood (GLOF) event. This, combined with a failure to engage local communities over time, led to the abandonment of the GLOF warning equipment.[11] According to the authors of the case study, "Without proper maintenance the system has gradually deteriorated to its present non-functional

WRR EXPERT PAPER

FRANCES SEYMOUR: "Governments will have to challenge vested interests in the status quo, and allocate significant investment to build the necessary institutional infrastructure that is currently lacking at all levels. Such infrastructure is needed to link local communities with higher levels of government, to facilitate inter-sectoral collaboration, and to enable citizens to have meaningful voice in the design of adaptation and mitigation strategies. But this investment entails few short-term/long-term trade-offs, as many of the same governance and institutional capacities needed to respond to immediate development needs and disaster risk reduction are the same as those necessary to prepare for climate change in the long run."

— Frances Seymour, Director-General, CIFOR

WRR EXPERT PAPER

PHILIP GWAGE: "Although governmental, social, environmental and legal frameworks and programs exist in developing countries, re-enforcement mechanisms are generally weak, resulting in policies which are decorating bookshelves and gathering dust. While generally decision making is not an issue because of the desire of many developing country governments to minimize vulnerability of infrastructure, natural resources, ecosystems and communities, the means required for full and effective implementation of adaptation decisions at national, local government and community level is lacking. There are many competing needs at the time of making the resource allocation decision and also lack of technical and weak institutional capacity."

— Philip Gwage, Department of Meteorology, Uganda

state. A small flood damaged the GLOF sensor, and gradually . . . equipment from the warning stations was stolen. Solar panels and batteries were the first to disappear."[12]

In Mali, the government's ability to incorporate climate risks in its agriculture sector was partly based on the long-term support, extending over two decades, of its principal donor, the Swiss Agency for Development and Cooperation, as well as technical back-up from the World Meteorological Organization.

CREDIT LINES AND INSURANCE

There will also be a need for donor-guaranteed credit lines and insurance (for example, through staggered payments, some of which can be made up-front) that can be accessed quickly to respond to extreme events. Extreme events can quickly deplete a government's finances and destroy infrastructure vital to the everyday functioning of society. Access to insurance and credit markets can help reduce and transfer the risks associated with such disasters.[13] Relief and rehabilitation efforts will require long-term financial assistance to rebuild critical facilities such as schools and hospitals, roads and bridges.[14] It should be noted, however, that not all injections of financial resources for recovery efforts are beneficial. Sometimes the infusion of financial resources and rebuilding activities can lead to greater vulnerability, for example, if rebuilding fails to take into account future climate risks. Quick fixes may not only reinforce these risks but also have the potential to increase them.[15]

Vulnerable communities and sectors can strengthen their protection against the loss of resources in the face of extreme events by adopting risk transfer strategies, such as insurance. Insurance can help provide quick access to resources, speeding recovery.[16] Properly set premiums[17] can prevent risky activities or incentivize prevention efforts.[18] However, policymakers considering insurance mechanisms as an adaptation approach should be careful to balance risk prevention and risk transfer.[19] Clearly, insurance does not prevent loss of lives and other direct losses.[20] Furthermore, these mechanisms often fail to reach the poor and most vulnerable.[21] If poorly designed, insurance can also lead to maladaptation, providing incentives for the adoption of more risky behavior.[22] For example, crop insurance can lead to the perverse effect of farmers allowing crops to die in order to collect insurance payouts that are higher than a poor growing season's earnings.[23]

Box 7.1 Building Capacity: UNDP's Africa Adaptation Programme

Many developing countries urgently need to invest in the institutional and human capacities that will be required to meet the challenges of climate change. A unique partnership between the Government of Japan and the United Nations Development Programme (UNDP) is working to address the pressing need to build capacity in 20 African countries. The African Adaptation Programme (AAP) draws on UNDP's long-time development and institutional expertise. The partnership also recognizes that development projects often get implemented in countries irrespective of whether sufficient capacity exists to take full advantage of them.

The AAP is a strategic initiative aimed at creating an operating environment in which adaptation policies and decisions are informed and effective, recognizing the essential connection between development and adaptation. The goal is not to sponsor or promote specific adaptation projects but rather to support each country as it builds the organizational structure, the technical capacity, and the human skills and capacities to address the short- and long-term impacts of climate change on development.

According to one senior AAP official, "The biggest hurdle we faced at the start was overcoming the project mentality that exists in many organizations. We wanted to create something lasting. This is one of the first programs with the emphasis on outcomes that are not so physically tangible, but which are absolutely necessary to effective operations in these countries as they manage climate change and development."

While each country has a dedicated UNDP office and team working with it to address unique national challenges, there are back-up teams of special advisers available to step in and help deal with particularly difficult issues. In addition, there is a central unit in the AAP headquarters in Dakar, Senegal, to provide support services to all countries in the program. The services include access to best scientific data on climate variability, sharing of best practices from other countries, and information about new financial options and how to access them.

The program was launched in late 2008 with a grant of US$92 million from the Japanese government and is headquartered in Dakar, Senegal. Countries currently taking part in the African Adaptation Programme are Burkina Faso, Cameroon, Congo, Ethiopia, Gabon, Ghana, Kenya, Lesotho, Malawi, Mauritius, Morocco, Mozambique, Namibia, Niger, Nigeria, Rwanda, São Tome and Principe, Senegal, Tanzania, and Tunisia.

Nevertheless, there are an increasing number of examples that hold promise for the broader application of insurance to climate change. Mongolia has adopted index-based livestock mortality insurance, which avoids some of the pitfalls described above (see Mongolia case study p. 119). Communities lacking formal insurance may still prepare for climate impacts by creating self-insurance measures. For example, some rural communities have chosen to build up their assets, such as livestock, between extreme events so they can be sold off when another disaster hits. In El Salvador, households in slum areas have spent as much as nine percent of their income on bolstering the walls of their homes to prepare for floods.[24] The challenge, however, is that such measures often fail during an extreme weather or climate event.[25]

SHIFTING FROM "HARD" INVESTMENTS

Adaptation financing should not focus solely or even primarily on built infrastructure in lieu of building skills and capacity of decision makers and communities to adapt. Investments should increasingly shift to support activities that are able to withstand climate risks, such as building technical know-how, strengthening information systems, and enhancing coordination, among other investments we discuss throughout this report. This may require a shift in donor strategy. The capacities required for effective decision making may be more difficult to quantify and may not bring short-term returns. Current donor trends toward results-based lending, or lending dependent on the achievement of results and performance indicators, may not be well suited to financing core-capacity development, which may take longer to achieve.

A shift away from investing in "brick and mortar"[26] resources can also allow for investments to be dedicated to strengthening ecological resources. While more research is needed to understand the short- and long-term resilience of ecosystem-based adaptation measures versus built interventions,[27] ecosystem-based approaches to adaptation can often be more flexible and less costly.[28] Opportunities for ecosystem-based adaptation, explained in more detail later in this chapter, include restoration of wetlands to restore water resources for hydroelectric power (see Rwanda case study p. 84).

Human Resources

Many developing countries sorely lack the human capital required to prepare their societies for impending climate impacts. Many of our case studies cited as a problem the deficiencies in the technical capacity and training needed to develop, implement, and monitor adaptation initiatives.

In Brazil, the Acre state government established a fast-reacting situation room to process satellite data recording forest fires in order to enable rapid responses to assist affected communities. The authorities had the majority of data needed at their disposal and were able to pinpoint those areas most in need. But the government was not able to deploy sufficient numbers of firefighters because of both the nature of the terrain and the lack of availability of personnel (see Brazil case study p. 81).

In Namibia, long-standing successful initiatives to conduct farmer-led local-level monitoring of land and farming conditions in poor rural regions are at times undermined by a lack of continuity among staff and participants. Turnover is high among representatives of partner organizations, such as extension service providers and NGOs.[29]

In Rwanda, insufficient capacity to oversee, implement, and monitor restrictions on agricultural and drainage activities weakened the effectiveness of measures to revive degraded wetlands to ensure an adequate water supply for hydropower production.[30]

Efforts to integrate climate risks to ecosystems into planning in South Africa benefited from strong local capacity to perform risk assessments that were in turn fed into biodiversity plans to inform municipal authorities. However, the lack of formal training to implement both bioregional plans and the country's National Protected Area Expansion Strategy remains a barrier to the adoption of appropriate adaptation measures.[31]

Bangladesh, which typically experiences annual flooding affecting 10 million citizens, has gone further than most developing countries in prioritizing activities to strengthen officials' knowledge and capacity to manage risks posed by climate extremes. A training program was established as part of the government's Comprehensive Disaster Management Programme, with

Box 7.2 Ecosystem-Based Adaptation

Ecosystem-based adaptation (EbA), as its name implies, refers to the deliberate incorporation of ecosystems, such as forests and wetlands, into adaptation strategies. EbA policies, measures, or activities consider the role and value of ecosystem services (such as water purification and storm damage mitigation) in reducing the vulnerability of both society and ecosystems themselves to climate change. [33]

In practice, EbA can take many forms, such as managing shrublands and forests to reduce the risk of forest fires or rehabilitating coastal ecosystems to protect against storm surges while increasing economic benefits for those who depend on them for their livelihoods.[34]

Such EbA activities stand to benefit a wide array of objectives, including poverty alleviation, climate change adaptation, disaster risk reduction, and conservation.[35] It is vitally important to recognize that ecosystems themselves need to be resilient in a changing climate if they are to provide the services that communities rely on. Thus, additional measures focusing on adaptation for ecosystems may be necessary and should be incorporated into EbA measures.

Box 7.3 Assessing the Risks to Agriculture from Climate and Ecosystem Change in Southern India

Step 1: Identify priority ecosystem services by systematically evaluating the risk from the dependence and impact of agriculture on each ecosystem service. Food production in southern India depends on or impacts freshwater, pollination, water regulation, erosion control, natural pest regulation, and nutrient cycling.

Step 2: Analyze the condition and trends of each priority ecosystem service, including the effects of climate change and other drivers of ecosystem change. Freshwater: climate change will decrease overall rainfall while increasing its intensity. This greater intensity will increase run-off and decrease groundwater recharge rates. Pollination: increased temperatures will stress existing pollinators as well as plant pollination systems.

Step 3: Identify risks and opportunities stemming from each priority service. Freshwater: agriculture is responsible for 90% of water withdrawal and will cause demand to outstrip supply in nearly all areas of southern India by 2020, leading to reduced availability of water for irrigation and other uses. Pollination: reduced yields from insect-pollinated crops; heat dries maize silk, eroding its pollinating capacity.

Step 4: Develop strategies for managing risks. Freshwater: switch to crops that use less water and are more tolerant of extreme weather events, improve water efficiency, and restore landscape to manage water flows. Pollination: reduce non-climate stresses on pollinators through the use of integrated pest management, plant wildflowers to increase habitat and switch to wind-pollinated crops that are less sensitive to rising temperatures.[41]

25,000 officials trained since 2007. The government has also engaged universities to develop disaster management curricula.[32]

While there are many competing priorities for funding, building knowledge and technical capacities in government officials cannot be neglected. In many cases, these skills will have to be established in ministries that traditionally focus on only those skills that are occupational requirements of a job, such as engineering knowledge, requiring a shift in mind-set. Decision makers can also enlist the assistance of technical institutes and universities in such training efforts (see Box 7.1).

Ecological Resources

Ecosystems, such as forests, wetlands, and coral reefs provide goods and services such as clean water, food, climate regulation, fiber, and fuel that are vital to the well-being of human society. According to the UN Millennium Ecosystem Assessment, ecosystems have been degraded more rapidly over the past five decades than at any other point in human history, driven primarily by human activities. Ecosystem degradation has resulted in the loss of vital services and an unprecedented rate of species loss; it has also reduced ecosystem resilience. These trends are now being exacerbated by climate change (see Box 7.2).

While ecosystems will naturally adapt and evolve in response to climate change, this adaptation may alter the flow of ecosystem services and change existing species diversity in ways that are not advantageous for communities that depend upon them. This is especially true when ecosystems are also under pressure from other stressors (such as habitat conversion, invasive species, and pollution) such that they cannot adapt without losing their existing properties. To give just one example, freshwater shortages in Asia are projected to increase dramatically as a result of glacial melt due to climate change and overuse, negatively impacting more than one billion people in the next four decades.[36]

Ecosystems can play an important role in buffering risk. The rural poor, especially in the developing world, are especially dependent upon ecosystem services for their well-being and livelihoods.[37] A high percentage of their income is derived from natural resources such as forests and fisheries.[38]

Efforts to strengthen the resilience of ecosystems can enhance the adaptive capacity of human communities facing climate change risks, while at the same time providing co-benefits such as reducing greenhouse gas emissions and raising rural incomes by increasing ecosystem services that have market value. The "Economics of Ecosystems and Biodiversity" project (TEEB), undertaken by the United Nations Environment Programme's Green Economy Initiative, has demonstrated the economic benefits of conserving ecosystems. For example, efforts to protect coastal mangroves in Vietnam cost US$1.1 million, but because the government no longer had to maintain dikes, it also saved US$7.3 million annually.[39] Measures that increase the resilience of both ecosystems and communities can include efforts to strengthen sand dunes, wetlands, mangroves, forested slopes, and conservation-based water management for smallholder farming.[40]

Bruno Locatelli and Emilia Pramova of the Center for International Forestry Research (CIFOR) describe in a WRR Expert Paper how ecosystem-based adaptation can assist communities in a changing climate: "Mangroves protect coastal areas against storms and waves, forest products provide safety nets for local communities when agricultural crops fail and hydrological ecosystem services (such as base flow conservation, storm flow regulation, and erosion control) are of utmost importance for buffering the impacts of climate change on water users. The conservation and sustainable management of ecosystems and their services can generate multiple socio-ecological benefits and also promote long-term approaches to climate change adaptation."

Ecosystems can mitigate many natural hazards,[42] and maintenance of ecosystems can be less costly than building infrastructure such as dams or seawalls and can provide co-benefits to human communities, such as income-generating assets.[43] However, there are limits to ecosystems' ability to reduce risks. For example, once the sea level rises over a certain level, mangroves may no longer be able to provide protection (however, they can continue to provide services if land zoning allows them to retreat inland). More research is needed to identify these limits.

From a national government decision maker's perspective, it will be critical to evaluate how ecosystems themselves will be affected by climate change and how they can be made more resilient. Not only might critical ecosystem services, such as flood and erosion control, be lost, but irreversible change, such as loss of habitat and species, can occur. Of particular concern as well is the degradation of ecosystem services such as provision of freshwater, erosion control, pollination, and water regulation that underpin agriculture and food production worldwide.[44]

Rapid-assessment tools can be used to assess and integrate the multiple types of risks facing ecosystems. For example, the World Resources Institute has developed a tool that provides a rapid screen for how climate change and other ecosystem threats affect the flow of ecosystem services and how these in turn create risks to economic development goals.[45] This tool is especially useful for those sectors that depend heavily on ecosystems, such as water supply, agriculture, forestry, and power generation. Box 7.3 illustrates the application of the tool to agriculture in Southern India.

Climate extremes in particular will place a premium on rehabilitation,[46] restoration and conservation activities, as ecosystem-based adaptation efforts rely on healthy ecosystems. Such efforts are likely to be well worth the investment and can help address other pressing development challenges like food security and rural poverty. For many natural resource-rich developing countries, ecosystem-based approaches to adaptation may be a crucial component of national strategies for coping with climate change.

Box 7.4 Key Dimensions of Social Resources

The World Bank Social Capital Implementation Framework identified five key dimensions of social resources:[51]

- Groups and networks: collections of individuals who promote and protect personal relationships that improve welfare.
- Trust and solidarity: elements of interpersonal behavior that foster greater cohesion and more robust collective action.
- Collective action and cooperation: the ability of people to work together toward resolving communal issues.
- Social cohesion and inclusion: mitigates the risk of conflict and promotes equitable access to benefits of development by enhancing participation of the marginalized.
- Information and communication: breaks down negative social capital and also enables positive social capital by improving access to information.

Social Resources

From a development perspective, increasing adaptive capacity means enhancing the resources that an individual, household, or community may mobilize to build resilience to climate change. These include knowledge, human, financial, natural, physical, institutional and technological resources. Even though their importance often is underestimated, social resources are fundamental building blocks of resilience.

Social resources (also referred to as social capital or social assets) refer to the institutions, relationships, and norms that shape a society's social interactions. The value of social resources is twofold. First, they bond similar people together using ties of family, culture, socio-economic status, nationality, and community. Second, they serve as a bridge between diverse people, through the creation of norms of trust, reciprocity, and exchange.[47] Through these bonds and bridges, social resources can encourage coordination and cooperation for mutual benefit within vulnerable communities, enabling them to act collectively, cope with adverse conditions, and provide mutual support in times of crisis, such as an extreme event like a flood or drought. In addition, such bonded communities develop mechanisms to find and share other resources including ecological, human, and financial.[48] Importantly, social resources can provide a collective voice to vulnerable groups. This enables them to better influence decision makers as they make plans and policies that will affect how their communities will adapt to climate change.

Strong social resources also lead to the dissemination of good practices and policies, as the national level often learns from a variety of autonomous adaptation efforts. As communities interact with decision makers at the national level, they enable state institutions to evolve and improve.[49] Much as viable ecosystem resources help create conditions for effective risk management, social resources can help build adaptive capacity and resilience. This can occur through a wide range of activities, such as collective preventive action to raise the level of river embankments or simply by being able to trust a neighbor in a time of crisis.

Social resources differ in nature and composition from other assets or forms of capital. Unlike the other building blocks of adaptive capacity, social resources do not depreciate with use but, rather, with disuse.[50] Consequently, although some level of social resources will always exist even without governmental action, national-level decision makers have a significant role to play in creating and maintaining an environment for strong social resources to flourish (see Box 7.4).

They can do so in several ways. First, national decision makers can proactively build trust across levels of governance and with non-governmental actors by strengthening existing forms of social accountability. In recent years, the range of mechanisms for social accountability has broadened significantly, and today includes participatory public policymaking, participatory budgeting, public expenditure tracking, citizen monitoring, and evaluation of public service delivery.[52]

By bringing vulnerable and marginalized communities into the decision-making process, government officials provide a platform for action, mutual learning, and collective problem solving. Ultimately such investment on the part of government ensures greater local support and ownership of adaptation interventions (see Chapter 3). However, the public's ability to engage effectively is often constrained by a lack of human and financial resources. Governments can address this by bolstering the organizational capacity of vulnerable and marginalized groups.

Second, governments can improve social resources by investing in communication technologies that encourage interaction beyond face-to-face meetings. Although intended for the more narrow purpose of getting information to the local level, these improvements in communication infrastructure boost the community's social resources by providing a greater sense of interconnectedness.

The benefits of social resources can be tangible. For example, community-organized water user groups in the Philippines and Sri Lanka have worked together to decide on rules and procedures for irrigating their farmland. Results have included increased yields, greater equity in water use, and fewer complaints to the government. In Malawi, a program offering insurance for groundnut and maize farmers has spread good agricultural practices, allowed groups to pool their resources and manage property as a cooperative, and provided access to credit for communities that would typically lack financial resources. Insurance payments are triggered if there is insufficient rain during the planting season. The success of the program to date rests on the participation of small-scale farmer groups in designing the insurance packages.[53] Programs like these will be increasingly necessary as climate change affects agricultural output and water availability.

Social resources are often deployed as a last resort or fallback measure; for example, if a government fails to properly prepare its citizens for a disaster, communities will be forced to rely on the social relationships they have formed. This is particularly true of countries that already face multiple non-climate stresses resulting from under-development, chronic poverty, poor governance, and state fragility. As a result, from a decision maker's perspective, ensuring the emergence and sustainability of social resources becomes a crucial and cost-effective means of building communities' capacity to adapt to a changing climate.

The next chapter highlights key findings and recommendations based on the research commissioned for this report. It seeks to provide context and priorities for government officials, donors, civil society organizations, and others seeking to integrate climate risk into national planning and policymaking, particularly in the developing world.

CASE STUDY

SOUTH AFRICA: Ecosystem-Based Planning for Climate Change

SOUTH AFRICA IS ONE OF THE WORLD'S MEGADIVERSE COUNTRIES, HOME TO ALMOST 10 PERCENT OF the Earth's total known bird, fish, and plant species; more than six percent of its mammal and reptile species; and almost 15 percent of its known coastal and marine species.

Caroline Petersen, South African National Biodiversity Institute

Stephen Holness, South African National Parks

This biodiversity is increasingly threatened, however, by a range of human activities, including rapid urban expansion, growth in the agricultural and mining sectors, and pressure on natural resources such as fish stocks, rangelands, and water.

Climate change threatens to compound these existing threats, with South Africa likely to face temperature rises of 1 to 3 degrees Celsius, more droughts and floods, decreased river flows, and more frequent wildfires.[1] Predicted impacts on the country's biodiversity include major shifts in range for species and ecosystems. Secondary factors, like the emergence of such new industries as biofuel crops and the construction of large dams to accommodate changes in water supply, may also affect biodiversity.

In response, South Africa is pursuing a strategy of ecosystem-based adaptation to climate change, with the goal of maintaining a sufficient, intact natural habitat, identified through systematic biodiversity planning.

To this end, over the last decade, South Africa has incorporated biodiversity information into its land use and development planning and has created a national strategy for expanding protected areas to conserve biodiversity and promote the resilience of ecosystems.

The objective is to steer local planners away from activities that would increase vulnerability to climate change.

The vehicle for implementing this strategy is biodiversity-sector planning, part of which requires the drawing up of maps of both critical biodiversity areas and ecosystem support areas. These maps are being used in seven of the country's nine provinces and offer a wide range of information about a given area's biodiversity features, as well as its patterns of land and resource use.

Conservation planners then set quantitative biodiversity targets for habitat types, ecological processes, and/or species. For example, they determine the minimum range requirements for

a threatened animal species. This information is then analyzed using specialized, GIS-linked software programs to form the basis for systematic biodiversity plans. These plans focus on land use solutions that meet the biodiversity targets set for a particular area in ways that will be the least costly to society and cause the least amount of conflict with other valid land uses. The plans highlight areas where conservation should be prioritized and identify those of less conservation interest that could be developed more safely. Biodiversity plans typically are based on the needs of habitats and ecological processes rather than individual species.

Over the past three years, conservation planners have concentrated on aligning biodiversity priority areas with areas of intact natural habitat that are essential to maintaining landscape-scale ecological functions and the services they provide to people. These priority areas also are aligned with biophysical features that support ecosystem-based adaptations to climate change, including intact river and coastal corridors, mountain ranges, and areas with a variety of microclimates.

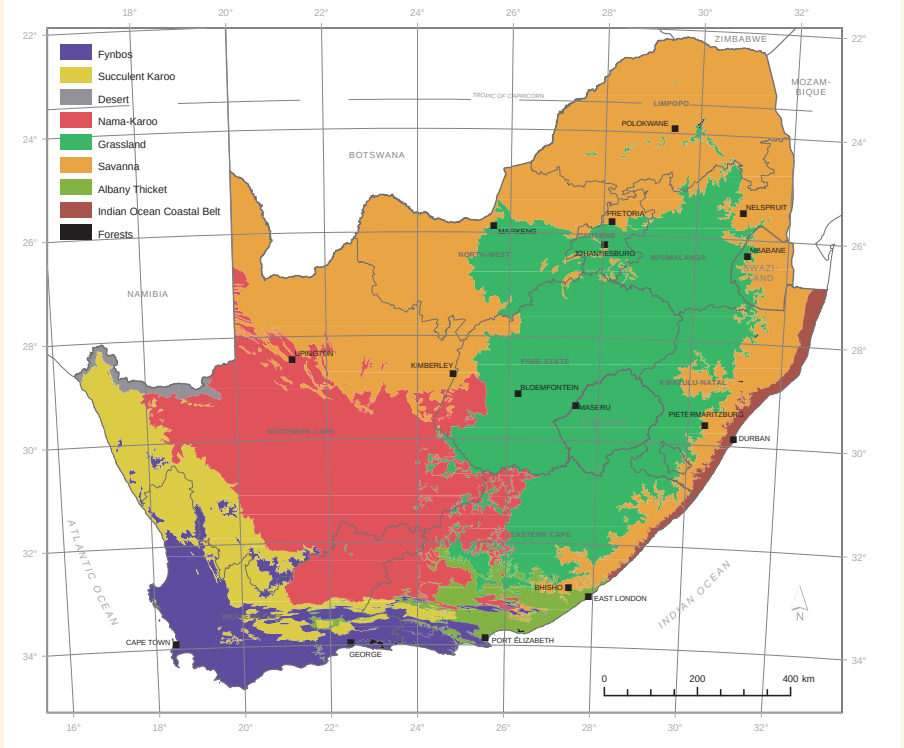
Along with large, intact areas of biodiversity, habitat corridors are critical not only to allowing plant and animal species to move in response to climate change but also to helping human communities adapt. For example, maintaining indigenous vegetation along rivers can provide corridors for native species as well as prevent the banks from being eroded when rivers swell during heavy rainfall.

In some areas of South Africa, efforts are being made to implement biodiversity plans on the ground, with biodiversity and climate change adaptation priorities taken into account in the policies, programs, and day-to-day work of such relevant economic sectors as housing, agriculture, and industry. For example, maps have been integrated into environmental impact assessments and are accompanied by land use guidelines.[2] The objective is to steer local planners away from activities that would increase vulnerability to climate change, such as cutting off a corridor needed for species to migrate as temperatures rise.

Municipal and provincial officials and the public have access to interactive maps and global information system data layers (e.g. layering current critical biodiversity maps with projections of ecosystem change due to climate change). These constituencies can then use this information to assess the impact and value of various new activities and investments.

The current legal requirement is for systematic biodiversity plans that ensure the long-term preservation of biodiversity and that take ecological processes into account. Although the guidance does not explicitly mention climate change, the latest plans incorporate climate change design principles that are widely accepted by the conservation-planning community as necessary for all future plans.

Vegetation Map of South Africa, Lesotho and Swaziland



SOURCE: Mucina, L. & Rutherford, M.C. (eds) 2006. The Vegetation of South Africa, Lesotho and Swaziland. Strelitzia 19. South African National Biodiversity Institute, Pretoria.

ENDNOTES

1 DEA 2009.
2 Petersen et al. 2010.
3 Petersen et al. 2010.

LESSONS LEARNED

Efforts to integrate climate risks to ecosystems into planning in South Africa have benefited from the country's strong local capacity to perform risk assessments. This information is fed into biodiversity plans that inform the decisions made by municipal authorities. However, the lack of formal training for implementing bioregional plans and the lack of financial resources for the full implementation of the National Protected Area Expansion Strategy have been barriers to their adoption.[3]

Some provinces and districts have made significant progress from merely having plans in place to actually implementing them. But because these plans have not yet been recognized as pressing national priorities, they must compete for resources with many other development challenges. The lesson here is that having state-of-the-art biodiversity planning products in place does not guarantee that they will be used effectively to guide appropriate development or wise biodiversity management. Accordingly, more active capacity-building efforts are required for land use planners, decision makers, scientists, NGOs, and other implementers.

CASE STUDY

MONGOLIA: Coping with Extreme Events Using Index-Based Insurance

IN MONGOLIA'S GRASSY STEPPE PASTURES, HERDING IS THE ECONOMY'S LIFEBLOOD, EMPLOYING AROUND 40 percent of the nation's workforce. About 44 million head of livestock — cattle, sheep, yaks, goats, horses, and camels — were counted in the National Statistical Office's 2009 census. Many Mongolians depend on these animals for food as well as income, and livestock can also serve as a social safety net when other livelihood options have been exhausted.

Kirsten Luxbacher, Independent Consultant

Andrew Goodland, World Bank

This reliance on herding leaves rural households and the Mongolian economy (livestock makes up 20 percent of GDP) vulnerable to shocks that affect livestock populations. Unfortunately, such shocks are not uncommon, as the nation's climate is harsh and its weather highly variable, changing greatly not only seasonally but also daily. This vulnerability to harsh weather and extreme events is intensified by the practice of herders grazing their animals over large swaths of grassland with limited shelter, a practice characterized as "low input, high risk, low output."[1]

Herders thus are particularly vulnerable to severe winter weather events known as dzuds, which can decimate livestock herds, triggering significant financial losses. After several especially severe dzuds between 2000 and 2002, major losses brought livestock risk management to the forefront of national policy discussions. Since then, the government has launched efforts to shift from relying on donors for post-disaster relief to a proactive risk management strategy for its livestock sector that it hopes will reduce its reliance on donors.

One component of this strategy is the Index-Based Livestock Insurance Project, an innovative approach intended to help herders cope with significant herd losses and transfer some of the risks of raising livestock. The project was launched on a trial basis in 2006, with the assistance of the World Bank and the Japanese government (it now also receives financing from the Swiss and Korean governments) in three of the country's aimags (provinces).

The results have been promising, and the project is set to expand nationwide by 2012, thus offering a model for other developing countries dealing with frequent severe weather events.

In the four years since the project was launched... on each [severe weather] occasion, the system proved effective.

SUMMARY OF INSURANCE PRODUCTS

Base Insurance Product (BIP) / Livestock Risk Insurance (LRI): This is a commercial product sold by private insurance companies. Payouts are triggered when livestock mortality rates in a soum (provincial district) reach between 6 and 30 percent. BIP was renamed as LRI during the 2009/2010 insurance cycle.

Disaster Response Product (DRP): A social safety net for herders, this product is offered and financed by the Government of Mongolia. Payouts are triggered when livestock mortality rates in a soum exceed 30 percent. During the pilot project, all herders who bought the Base Insurance Product were automatically enrolled in the Disaster Response Product. Herders who did not want to purchase the Base Insurance Product could pay a small fee to enroll in the Disaster Response Product. During the 2009/2010 insurance cycle, the DRP was discontinued and replaced by the GCC.

Government Catastrophic Coverage (GCC): GCC was created to replace the Disaster Response Product for policyholders, covering losses in excess of 30 percent. It differs from the Disaster Response Product in that it is available only to those herders who have purchased Livestock Risk Insurance and it covers only the value of the livestock insured.

SOURCES: Mahul et al. 2009; Skees et al. 2009.

INNOVATIVE USE OF INDEX INSURANCE

In 2001, to help it devise a new risk management strategy for the livestock sector, the Mongolian government turned to the World Bank for assistance. The result was a bank-funded feasibility study that recommended an index-based insurance approach, and in 2004 the government passed a new insurance law that paved the way for the pilot project.

The insurance scheme works by making payouts to herders based on aggregate livestock mortality rates in their district rather than on their individual loss. The project offers market-based insurance, as well as disaster coverage, provided by the government in case of catastrophes.

In rural economies, index-based insurance offers several advantages over traditional indemnity insurance. It lowers transaction costs because the company does not have to travel across remote areas to visit individual farmers. It reduces the occurrence of "moral hazard," that is, a herder's letting animals die in order to collect on a policy. And it can deliver a much quicker turnaround in payments, a key benefit for poor rural families.

Mongolia's project has been implemented by a government unit overseen by a steering committee representing several government departments and chaired by the state secretary of finance. Comprehensive outreach to herders not accustomed to taking out insurance has included television and print advertising, pamphlets, and even playing cards, as well as face-to-face training.

In the four years since the project was launched, with World Bank support, severe weather has triggered the base insurance three times and the disaster insurance twice. On each occasion, the system proved effective, with all eligible herders receiving the indemnity payments owed. From 2006 through 2010, 3.2 million head of livestock were insured, even though owners typically cover only 30 percent of their herd.

DZUDS AND RISKS TO LIVELIHOODS

Dzuds are characterized by one or more of the following: very low temperatures, wind, snow, and ice that prevent livestock from reaching pastures or receiving sufficient food and fodder.[2]

More extreme *dzuds* are often preceded by dry summers and little availability of pastures, so the animals are not in good condition going into winter.

High rates of livestock mortality are often difficult to prevent during a severe weather event even if adequate pastoral risk management strategies (such as winter shelters, fodder crop production, and storage) are in place.[3]

The financial losses from *dzuds* may be enormous. In the winters of 2000, 2001, and 2002, more than 11 million animals died, with a total value of US$200 million.[4]

In the future, climate change is likely to increase the variability and risks associated with these events.[5]

LESSONS LEARNED

High-quality data on livestock mortality, outreach efforts to educate herders on the insurance products, and capacity building by government officials, insurance companies, and financial institutions all have contributed to the success of the Index-Based Livestock Insurance Project. As a result, three companies signed up to sell the insurance in 2006, and four companies in 2007/2008.

Challenges remain, including redesigning the insurance to limit the government's exposure, a decline in the price of cashmere that affected herders' incomes, and inefficiencies in the way the insurance is sold. But the project's performance has exceeded expectations, representing a successful, proactive effort by the national government to respond to climate shocks before they occur.

ENDNOTES

1 Goodland n.d.
2 Sayed 2010.
3 Mahul et al. 2009.
4 GlobalAgRisk 2010; Mahul et al. 2009.
5 Luxbacher et al. 2010b.

8 CHAPTER FINDINGS RECOMMEN

OVER THE LAST 18 MONTHS, WE HAVE ASSEMBLED A WIDE-RANGING and extensive body of research materials: expert papers, case studies, simulation exercises, roundtables, and other issue-specific research materials from over 100 officials and practitioners from around the world. We have interviewed and met with many other experts involved in climate change adaptation issues. It is from this wealth of information that we develop our findings and the context for our recommendations, which we present below, followed by the recommendations themselves.

FINDINGS AND CONTEXT FOR RECOMMENDATIONS

The impacts associated with a changing climate are already rapidly changing our world.

As recent floods and droughts across Australia, Brazil, Pakistan, Russia and other countries have demonstrated all too clearly, extreme events are testing the ability of decision makers to react quickly and effectively.[1] Moreover, these extreme events have been occurring against the backdrop of heightened variability and long-term change, such as sea level rise and glacier melt, that promise significant disruptions for life in the not-too-distant future.

Earth's global average surface temperature is already rising at an accelerating pace, having already warmed 0.8°Celsius (1.4°F) since pre-industrial times.[2] And since there is a lag in climate response, due to the oceans' trapping of heat, the world is already locked into 0.6°C (1.1°F) more warming—even if we were to stabilize atmospheric concentrations of greenhouse gases today.[3] Early impacts are already apparent. Daily minimum temperatures have increased at a faster rate than maximum temperatures, with implications for freezing points and growing seasons.[4] Seawater has expanded due to warming ocean temperatures, and combined with melting glaciers and ice caps to trigger an acceleration in sea level rise.[5] The oceans have become more acidic, with profound negative impacts on shellfish, corals, and the communities that rely upon them. Rain and snowfall patterns have been changing too. Since 1900, some regions, including eastern North and South America, northern Europe, and northern and central Asia, have become wetter; others, such as the Sahel, Mediterranean, southern Africa, and regions of South Asia, have become drier. Most regions of the world, especially in the

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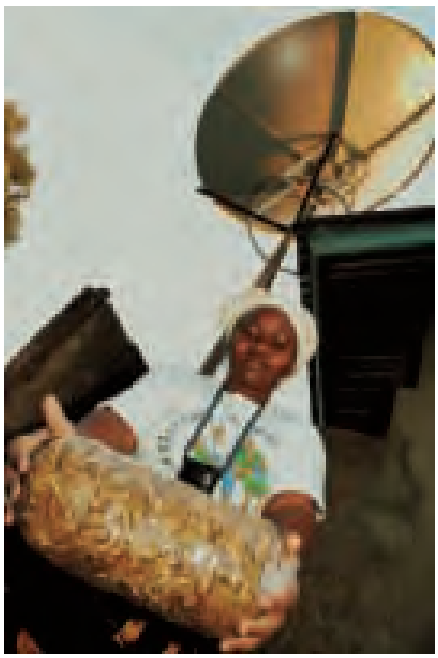
springtime, have experienced diminishing snow cover,[6] with implications for forest fires, water availability, and growing seasons. In short, the impacts of a changing climate are not distant phenomena; they are real and present today.

The impacts of a changing climate, some of which will be irreversible, necessitate deep and fast cuts in greenhouse gas emissions.

If greenhouse gas emissions continue unchecked, the impacts that result will likely trigger major shifts in social and ecological systems. While adaptation efforts can help offset some of the negative impacts of climate change, governments should not view adaptation as a substitute for reducing emissions. Rather they should pursue adaptation and mitigation at the same time and as a matter of urgency. While it may be difficult to accept, societies and governments should also recognize that some goals of adaptation will not be achievable. Some impacts, such as the loss of ice sheets, unique cultures, and species diversity, will be irreversible.[7] The potential scale of climate impacts underscores the urgent need for greenhouse gas reductions; the warmer the planet is, the more difficult it will be to attain adaptation objectives.



The vulnerability of affected populations and ecosystems will dictate the social and ecological outcomes of climate change.

Climate impacts will vary between, and often within, regions, countries, and localities, based on the vulnerability of affected people and ecosystems. It is therefore critically important for decision makers to consider differences in vulnerability among affected populations when designing interventions. Vulnerability to climate change can be affected by a variety of social, economic, ecological and political factors that increase exposure, sensitivity, or the ability to respond to climate change. Taking these factors into account can help governments target the poor and vulnerable members of society and link climate adaptation to mainstream development efforts.

Indeed, addressing climate risks can provide a unique opportunity to confront other poverty-related risks and reduce overall vulnerability. Governments can take advantage of this confluence of interests by integrating climate risk management into ministries for economic development, finance, and relevant sectors and establishing a central agency to coordinate their adaptation efforts.

WRR EXPERT PAPER

NICOLA RANGER AND SU-LIN GARBETT-SHIELS: "If climate change is not considered upfront in existing planning and policymaking processes today, decision-makers risk locking in future impacts that may prove irreversible or much more costly and difficult to rectify than is necessary… For example, existing infrastructure and social policies (such as urban planning) may not be suitable in a warmer climate and in some cases this could lead to greater damages from climate-related risks and slower economic growth and development."

— Nicola Ranger and Su-Lin Garbett-Shiels

The scale, pace, and complexity of the risks posed by climate change require a different approach to decision making than in the past.

The underlying nature of climate change poses significant challenges to decision making. For example, recent science suggests that many climate impacts are not advancing linearly.[8] There may be incremental changes that, if we fail to act now, could manifest themselves as potentially irreversible change decades later. Climate change also can exacerbate existing ecosystem stressors, such as land conversion and pollution. This in turn can bring physical, hydrological, and ecological systems closer to critical thresholds than they would be in the absence of climate change. Further complicating decision making, there are some impacts that decision makers will not be able to assign a probability to nor anticipate.

A changing climate will also necessitate that both the specific risks to any given country, region, sector or community, and the vulnerability of those affected, be explicitly incorporated in decision-making processes. Many governments and donors still treat adaptation in a compartmentalized, project-based manner.[9] They may also view it narrowly as an environmental problem rather than a development issue. Climate risks must be integrated throughout national, sectoral, and sub-national planning and policymaking, as well as in donor investments.

To prepare effectively for climate impacts and protect the most vulnerable members of society, decision makers should select approaches that are responsive, proactive, flexible, durable, or robust, depending on the type of change at hand.

As discussed in Chapter 2, decision making should be designed to be both more responsive in the aftermath of an extreme event, and increasingly proactive to prepare for future extremes. To contend with heightened variability, decision making should be flexible in order to adjust to impacts as they unfold and to new information. And for long-term change, decision making should be proactive, durable, and also flexible to account for the dynamism of climate impacts that will occur over decades. Finally, decision making must be robust in the face of various possible futures, given the uncertainty clouding how climate risks will unfold on the ground.

Public engagement, information systems, institutions, decision-support tools, and financial, human, ecological, and social resources are key elements that can equip planners and policymakers in making effective decisions in a changing climate.

As we have demonstrated in Chapters 3-7, drawn from the broad range of research commissioned for *World Resources 2010–2011*, effective design and use of these five elements can lead to adaptation decisions that result in greater resilience to climate change impacts.

The profound risks posed by a changing climate will require decision makers to make difficult choices.

A changing climate will present difficult trade-offs and choices, especially in the developing world, given the substantial resource constraints. There are undoubtedly some "low regrets" adaptation measures that governments can take which can contribute to urgent national development or poverty alleviation goals while also enhancing climate resilience. However, there will be generational trade-offs inherent in the choice between how much to invest in addressing today's urgent problems versus tomorrow's. Should a West African country with severely limited resources, for example, prioritize addressing the spread of HIV, or preparing physical defenses against predicted sea level rise that will swamp its coastal cities? Similar trade-offs loom regarding which populations and which ecosystems will be prioritized by adaptation efforts and which will lose out.

With each degree of warming, more physical, ecological, and societal systems will be placed at limits beyond which adaptation efforts will not be effective (such as the disappearance of glaciers). These limits to adaptation will be subjective—for example, some communities may consider the inundation of a coastal area by rising seas to be unacceptable and to be avoided at all costs, while others may concede its inevitability.[10] Therefore, inherent in these difficult choices associated with adaptation decision making is the need to weigh various interests and values, especially of the most vulnerable segments of society.

These are choices that government officials alone should not make. As a first step, national governments should engage those affected to determine acceptable levels of risk and to prioritize

adaptation actions. Affected communities and constituencies also need to be engaged in targeted adaptation policy and planning processes, in order both to build support for the choices made, and to improve the effectiveness of actions taken. Public engagement in deciding what types and levels of risk communities or constituencies are willing to absorb will enable those affected to have a voice in deciding priorities and is critical to ensuring fair processes and maintaining legitimacy and trust in government actions.

For some decisions, a stepwise approach can be taken that keeps future options open and avoids "lock-in" to future vulnerability.

For some decisions, short-term courses of action can be taken that keep open future options as circumstances change. A stepwise approach of this kind can help decision makers to develop decisions that can incorporate new information and evolving conditions. In this way, resource-limited countries can consider long-term climate risks even very uncertain ones—in planning and policymaking while focusing on short-term measures (see Box 2.6). Decision makers who adopt a stepwise approach should carefully and continuously monitor key indicators (e.g. sea level rise) that help to reduce uncertainty about when changing circumstances warrant a revision of plan or policy. Such an approach also requires information about where thresholds (or a range of possible thresholds) lie that would undermine the effectiveness of decisions taken. For example, rainfall above or below a certain level might affect the operation of a hydroelectric dam, or a certain level of seawater rise might breach coastal defenses.

In addition, stepwise measures can include "low regrets"[11] measures that further development and poverty reduction or enhance ecosystem resilience, and so reduce vulnerability over the long term. Many developing countries are sorely lacking in terms of the governance, infrastructure, and human capacity needed to address climate risks that are already impacting their populations and ecosystems. Under such circumstances, measures that build human capacity in governments can assist in fulfilling development objectives while strengthening their capacity to implement climate-resilient policies and plans. In addition, effective management of ecosystems can provide significant benefits to development and strengthen the ability to adapt to climate change at the same time. For example, measures that focus on increasing forest resilience in a changing climate can bolster the resilience of communities (see Box 8.1).

WRR EXPERT PAPER

FRANCES SEYMOUR: "In the short term, forests help to buffer communities and societies more broadly from the effects of current climate variability that they are already experiencing, such as droughts, storms, flooding, and landslides. For example, forests can provide a degree of physical protection to coastal areas from storms and waves, and forest-based ecosystem services can help regulate hydrological flows during years with abnormal rainfall. Forest-based foods and other products that can be consumed or sold for income provide a safety net when agricultural livelihoods are affected by drought. It is also increasingly recognized that by providing those functions, forests have an important role to play in helping people adapt to climate change in the longer term."

— Frances Seymour, Director-General, CIFOR

Box 8.1 Examples of Ecosystem Thresholds: Reefs and Wetlands

One example of an ecosystem threshold is warming-induced coral bleaching due to a loss of microscopic algae, which can lead to the large-scale death of coral reef populations. Due to abnormally high ocean temperatures in recent years, mass bleaching events have become increasingly more common and widespread.[12] Thresholds also exist in wetlands, which could experience groundwater loss due to increased water stress, thus making them highly susceptible to drying up in response to small shifts in temperature and precipitation.[13] Climate change may also lead to the movement of plant and animal species. For example, in a warming scenario, woody plants may invade a previously grassy area as it becomes a more hospitable habitat, which could result in rapid desertification due to increased competition for nutrients and moisture.[14]

However, for decisions with long-term consequences, decision makers will have to make early choices to take aggressive action with future risks in mind.

The consequences of some decisions made today will be hard to reverse, such as the location of new infrastructure such as power plants, landfills, or drinking water reservoirs or the location of housing developments for a growing coastal city. If climate risks are not taken into account in such decisions, investments may be lost and vulnerability may be increased. Therefore, these types of decisions will require planners to take early and often more aggressive action to guard against future risks from climate change.

When setting priorities, policymakers should be mindful of thresholds and may need to adopt a more aggressive approach.

The stepwise "wait and see" approach described above may not always be suitable or applicable for decision making in sectors highly dependent on ecosystems, such as agriculture, water, and forestry. Nor may it be appropriate for efforts to protect ecosystems themselves. While scientists have greatly advanced understanding of thresholds in ecosystems[15] uncertainty still surrounds where many of them actually lie.[16] And by the time such ecological thresholds are discovered, it may be too late to take preventive measures. This is particularly relevant in developing countries, where a greater share of income and livelihoods, not to mention the basic survival needs of hundreds of millions of people, depends on climate-sensitive ecosystems.[17] While it may be possible to plan for a series of different thresholds, the range of possible thresholds may be quite large, and there may not be time to wait for better information. Furthermore, "low regrets" options may not adequately prevent the crossing of thresholds. In these cases, decision makers may need to take more aggressive action, if feasible.

Research into thresholds should become a critical component of national adaptation efforts and international research priorities. In addition, if the overshoot of such thresholds will lead to significant, irreversible harm, more proactive measures may also be necessary to prevent this. For example, as our case studies in Rwanda and South Africa illustrate (see pp. 84 and 116), beleaguered natural systems may require protection from human activity in order to regenerate or to withstand climate impacts. Initiating such approaches on the scale required will in turn necessitate a major shift in strategies and priorities by donors, governments, and civil society organizations.

Existing long-term national plans and policies should integrate climate risks.

Many countries have long-term plans that inform future decisions over several decades, but have yet to take climate change into account. In some sectors, long-term plans, such as controversial water transfer projects in China and India could be affected by climate change and should incorporate climate risks. China's South-to-North Water Diversion Project, which largely aims to divert the Yangtze River from the water-rich South of the country to the more water-scarce North,[18] already faces significant uncertainty as to ecological and human impacts. In addition, planners may need to factor in the possibility of altered river flows due to climate change. India's ambitious Inter-River Linking Project, meanwhile, which intends to link rivers in order to reduce flood risk in the East and drought risk in the West and South,[19] will need to consider factors such as increased glacier melt and shifting rainfall patterns as the project goes forward. To promote their effectiveness, such long-term plans should integrate climate risks, and also allow for periodic assessment and revision, given the uncertainty of future climate change.

In the next section, we present the report's recommendations related to our five elements for effective decision making. It should be noted that proven examples of what works are few and far between, and that the

monitoring and evaluation of outcomes is often weak,[20] and lessons from research can be highly context-specific. Nevertheless, we provide these recommendations to highlight useful lessons that stem from our research.

While we structure the Report to discuss each of the five elements separately, and present our recommendations in the same way, readers should note the connections we have drawn between them—they do not and cannot stand alone. The elements all work together, self-reinforcing and interdependent, at various stages of the adaptation decision-making process. Decision-relevant information, for example, must often be collected at the local level, which puts a premium on effective public engagement strategies. At the same time, this may require institutional coordination efforts between national and local governments to ensure that information is disseminated to decision makers.

While readers may note that many of these recommendations would apply to many other public policy challenges, what calls attention to these elements and the accompanying recommendations is precisely the context in which they will be employed—the nature of climate change and its potential disruptive impacts. It is this context—decision making in a changing climate—that makes these elements and recommendations so important.

Box 8.2 Adaptation Decision Making in Practice: Ghana's Electricity Sector

Earlier in this report, we posed the question, "How should an energy planner in Ghana prepare for the future when projections suggest that national annual rainfall could vary from a 66 percent reduction to a 49 percent increase by 2050?"

Below we describe how the energy planner and his colleagues in the Ministry of Energy would proceed if they used the approaches we propose in this report in regard to the construction of a hydroelectric dam to meet current and future electricity needs. Our actual simulation exercise in Ghana, in which energy planners took part, used a similar scenario, described on page 98.

Given the large uncertainties over future national rainfall, and the implications for hydroelectric power, the planner in charge of the project would take the following steps:

- **Determine Decision Thresholds**
  The planner would assess what range of precipitation would compromise electricity production to such an extent that it would fail to meet its design specifications. After consulting with engineers, he might find out that if precipitation in 20 years is likely to be 33 percent lower than current levels, the dam, as currently designed, will be unable to generate sufficient electricity at an acceptable cost to users.
- **Engage those Affected to Determine Acceptable Levels of Risk**
  The planner would engage those affected by decisions about the dam to learn what level of risk would be acceptable to their interests. That group would include other industries and farmers sharing the same water source, as well as planned industries needing electricity to operate, and those who currently have no access to electricity. Given the projections—that rainfall could vary from a 66 percent decrease to a 49 percent increase by 2050—those making the decision will weigh the need for the dam against the acceptable level of risk to those whose interests will be affected.[21]
- **Decision Options**
  - Go ahead with the dam: In the WRR simulation exercise, the participants decided to go ahead with the dam.
  - Stop the dam: If those involved in assessing the dam agree that it is too risky, given the uncertainties about future rainfall, they might choose to propose other electricity-generating technologies, such as distributed generation of smaller hydroelectric dams, renewable energy technologies like solar or wind, or a conventional coal-fired plant.
  - Proceed in a stepwise manner: If decision makers chose this path, they would identify construction techniques or operational retrofits that would avoid locking in this future risk.
- **Monitor Long-Term Change**
  Indicators could be established that would monitor precipitation changes and inform decision makers whether precipitation is likely to be lower than the 33 percent threshold.
  - As that threshold comes closer, planners could identify ways to accommodate less precipitation, such as taking aggressive action upstream to conserve water, making operational changes, or improving the efficiency of, or replacing, the turbines.

RECOMMENDATIONS

1. Public Engagement

Governments should convey to the public the scale and range of the risks, including known uncertainties, and expected impacts of climate change.

Many members of the public will not be aware of the risks climate change poses to their livelihoods and safety. Because of this, governments should provide targeted information on the risks facing various sectors, regions, ecosystems and communities. This will help build support for activities undertaken. It will take time for officials and communities to absorb the reality of having to accept some losses, such as the inability to grow certain crop varieties, and even longer to become comfortable entertaining alternatives, such as relocation of certain communities, that will disrupt entrenched patterns of society.

Governments should recognize that public engagement processes can lead to better decisions and should not be treated as "rubber stamps" on a pre-determined policy or plan. Policymakers should build opportunities for public engagement into all steps of the decision-making process.

Engaging communities can build support for difficult adaptation choices as well as improve the quality of outcomes achieved. Public engagement throughout the entire policy process often is necessary to ensure the effectiveness and long-term viability of a policy or an activity. Civil society organizations can help facilitate this exchange between government and the public.

Specifically, governments should recognize the public as a vital contributor when prioritizing needs, providing information, determining acceptable levels of risk, and choosing among and implementing adaptation decisions.

The public, including affected communities and experts, often are more aware than national-level government officials of the needs that exist locally, as well as what types and levels of risk communities are willing to accept. By consulting with the public first, decision makers can increase the likelihood that plans truly serve the needs of those who are affected by them. When the setting of adaptation priorities involves difficult trade-offs, public engagement can facilitate understanding of choices and their consequences.

Governments should ensure that those affected by climate change have legal rights to be consulted and engaged in policy and planning processes.

Those most vulnerable often are the least consulted and engaged in planning and policymaking. In some situations, those affected will not have a right to participate in governmental decision-making processes. Securing rights to participation is a critical step in enhancing public engagement. International treaties such as the Aarhus Convention and a growing number of national laws have codified such rights as access to information, public engagement, and to justice.[22] Legal mechanisms such as these can help empower communities in the decision-making process.

Given the potential for disruption resulting from certain adaptation decisions, it is important that all groups know and understand that they have been accorded rights to participate. Not all decisions will be able to accommodate the concerns of all groups, but governments should endeavor to make sure that all groups have an opportunity to express their views.

Decision makers should make use of innovative methods when engaging the public.

Innovations, such as the use of games and videos, and incentives, such as providing bicycles or cell phones to farmers gathering local climate information, can promote public engagement in adaptation efforts and increase chances of success. Government officials should learn from the effective use of these innovations elsewhere and examine how they can be implemented in their own country. Methods of engaging the most vulnerable should be tailored to their different circumstances.

2. Decision-Relevant Information

Governments should collect, analyze, and distribute decision-relevant information about climate risks and vulnerability as a basis for action. Information users must be engaged in determining needs.

Many developing countries lack the basic infrastructure and capacity to gather and distribute adequate, accurate, and user-friendly information necessary for decision making. Systems established for collecting and disseminating relevant information should respond to users' needs.

Information for adaptation planning and policymaking goes far beyond climate information; demographic, economic, social, and environmental information is also vital if actions are to meet the needs of those affected.

While most efforts related to adaptation focus only on climate-related information, non-climate information is needed to assess the vulnerability of regions, infrastructure and populations and to understand what decision options are available for both short and long-term climate impacts.

Governments and donors should establish and fund long-term and regularly updated information management systems.

Information for adaptation decision making may require new funding models to ensure the necessary scope, continuity and analysis of this information. Approaches could include the design of effective, two-way information exchange systems between governments and communities and investments into basic information-gathering infrastructure such as weather monitoring stations. Long-term donor support can help advance and maintain such systems, as can donor strategies to strengthen governments' abilities to maintain these systems on their own over time.

Governments should target information dissemination strategies to reach vulnerable populations that will be most affected by climate change.

Information must reach those affected in a form that makes it useful for decision making. Dissemination methods must at times be rapid, particularly in the case of extreme events. They should also be capable of reaching remote communities, which may involve scaling up, where appropriate, information and communication technologies including text messaging and satellite communications devices. This is an area ripe for donor and private sector investment.

RECOMMENDATIONS (CONTINUED)

3. Institutional Design

Governments and donors should support the integration of climate risk management into ministries for economic development, finance, and relevant sectors, and they should consider appointing a dedicated central agency to coordinate all adaptation efforts.

Coordination among national agencies is critical to delivering effective responses to, and preparation for, climate change. Clear and effective coordination and communication is also essential between national agencies and local governments. Donors can greatly assist adaptation efforts by providing capacity building and technical support for coordinated approaches among national agencies and between across all levels of government.

Governments, donors, and civil society organizations should cultivate and reward strong leadership.

Governments, donors and civil society organizations can and should foster leadership at all levels through appointments and incentives, as the choice of agencies and individuals to take the lead on adaptation can make a significant difference in whether adaptation activities are prioritized and implemented effectively.

Governments should reform institutional mandates to better contend with climate risks.

Mandates to integrate climate risks into decisions will likely be required. This is especially true for long-term risks that would not typically be considered in plans and policies. For example, national funding to local or regional governments for road construction and improvement projects could be dependent on a mandate that all related projects include an assessment of potential climate impacts and how they will be managed. Other mandates that may be required to address climate risks include those that are longer term to ensure ongoing consideration of climate risks, those that establish mechanisms for rapid response, and those that allow for continuous policy updates.

4. Tools for Planning and Policymaking

Planners and policymakers should integrate climate risks into existing decision-making tools.

As they begin to account for climate change in policies and plans, officials should deploy common tools, such as environmental impact assessments and economic cost-benefit analyses, modified to integrate the risks posed by climate change.

Decision makers should also seek out innovative tools that are especially useful for planning for short- and long-term climate risks.

There are a number of tools that are not yet standard in the policymaker's toolkit that could prove useful for adaptation, such as decision support maps, predictive instruments, and scenario planning and simulation exercises. These tools show promise for scaling up for more widespread application.

Effective use of tools will require training and capacity building.

Many decision support tools require specialized knowledge. Governments and donors should fund training programs that give practitioners the skills necessary to use these tools.

5. Resources

Governments and donors should provide targeted and sustained funding delivered through fit-for-purpose mechanisms that respond to the unique challenges of climate change.

Because climate change will evolve over decades, long-term financial support from governments and donors will be essential to maintain initiatives and infrastructure and to ensure a return on their investments. Fit-for-purpose mechanisms will be necessary to provide access to longer-term financial support for activities such as the continuous collection of adequate, basic weather and climate data. In addition, countries will need access to secure credit lines that can be tapped quickly for extreme events; they will also need to shift away from "hard" investments to those that build capacity, and support softer investments such as maintaining ecological climate buffers.

Current donor trends towards results-based lending may not facilitate such investments. A key challenge for donors and others will be to create incentives for developing countries to integrate climate risks into decision making, so that this integration is seen as an opportunity and not merely another claim on scarce resources. It will also be necessary for donors to strengthen government capacity to implement activities, and create a clear and appropriate exit strategy to ensure government ownership.

Donors and governments should promote and fund technical training and strengthen human resources, which will enable more informed decision making.

Developing countries urgently need to build the knowledge, staff, and technical skills among public officials that will enable them to integrate climate risks into existing decision-making processes. Those capacities are necessary to create, implement, manage, monitor, and enforce adaptation strategies.

Donors, governments, and the public should take steps to protect and maintain basic ecosystem processes that provide a crucial buffer for adaptation processes.

Ecosystems can mitigate many natural hazards. Maintaining them can be less costly than building expensive infrastructure, while providing more benefits to society. Donors and governments should fund ecosystem monitoring programs and should take proactive measures to ensure that critical thresholds within ecosystems are not overshot so as to protect the services they provide. Measures must also be taken to ensure that ecosystems themselves are resilient in a changing climate. Accordingly, their ability to enhance the adaptive capacity of human communities will not be diminished.

National governments should enable the development of social resources, which can play a crucial role in building the adaptive capacity of vulnerable groups and populations.

Activities such as extensive public engagement in the policymaking process and investment in improved communications platforms can build interconnectedness among communities. By providing opportunities for the development of such social resources, governments can facilitate coordination and cooperation among communities, enable opportunities for collective action to provide safety nets in times of crisis, and develop mechanisms to share other forms of capital.

WORLD RESOURCES 2010-2011:
SELECTED INDICATORS OF POTENTIAL VULNERABILITY

One of the critical issues facing national government officials confronting climate change impacts and the decisions they demand is assessing the vulnerability of certain populations, regions, and sectors to those impacts, as described in Chapters 2 and 4.

Some countries are more vulnerable than others simply because of their location. Some countries, and some people within countries, are more vulnerable to climate change impacts because of economic circumstances, historical choices, governance, and other factors.

We have chosen to highlight four sets of data—out of hundreds that are available—because they are broadly applicable to many countries and because they represent some of the sectors that are likely to be significantly affected by changes in temperature and rainfall in the coming decades.

While these data may be useful at a national level as indicators of potential vulnerability, decision makers, as we discuss in depth in Chapter 4, will need a great deal more data in order to make effective adaptation choices. These will include basic socio-economic data and simple weather data—unavailable in many regions because of a lack of monitoring stations—among other data sets. Such data, when translated into usable information, will be critical to decision making at the national, regional and local levels.

The following maps graphically display these data by country.

1. The Center for International Earth Science Information Network (CIESIN) at Columbia University in New York City developed the data sets for populations living within 10 kilometers of a coastline. This represents one measure of potential vulnerability to sea level rise (CIESIN also generated data for 5km, but the results were not significantly different). The definition of coastline does not apply to landlocked bodies of water with no physical connection to oceans and seas.

   Most publicly available databases provide numbers for only those populations within 100 kilometers (60+ miles) of a coastline. We decided to provide data on a shorter distance to give another picture of potential vulnerability to sea level rise.

2. Agriculture accounts for 20 percent or more of GDP in 33 of the 182 countries in the data tables on pages 134-135; that figure does not include countries for which there are no recent, reliable data, such as Somalia, Niger, and Cameroon.[1] Agriculture that is largely dependent on rainfall is another broad indicator of potential vulnerability to climate change.

3. Many countries in Africa and Latin America depend on hydroelectric plants to generate more than 25 percent of their electricity. Between the twin impacts of glacial melt and changes in rainfall on both continents, this source of electricity may be vulnerable to climate change.

4. Water is the defining element in all of these indicators, but with different effects in each country. The Water Dependency Ratio, developed and maintained by the UN's Food and Agriculture Organization, communicates a very simple message: in a future in which water supplies may become scarcer or more unpredictable, vulnerability may be determined by who controls a country's source of water.

In all cases, we have presented the most recent data available. We have not combined these indicators for each country to produce a "vulnerability profile." Nonetheless, all countries will need to assess these and other factors as they incorporate the risks of climate change into their policy, planning, and other decision-making processes.

ENDNOTE

1 World Bank Data Catalog 2011.

Definitions, Sources, and Methodology for Selected Indicators

Population Living Within 10 km of a Coastline (2010): This indicator presents both the percentage of and the country's actual population that lives within 10 kilometers of a coastline. It does not include those populations that live near land-locked bodies of water.

Percentage of Agricultural Land Dependent on Rainfall (2000): This indicator represents the percentage of all agricultural land that is primarily dependent on rainfall. The values for each country are calculated by taking the difference between the total harvested land area in a country and the total irrigated harvested land area. The data on irrigated land area are derived from a global estimation of monthly irrigated and rainfed crop areas on a 5 arc-minute grid.[1]

Electricity Production from Hydroelectric Sources (percent of total, 2008, 2009): This indicator represents the percentage of a country's electricity generated from hydroelectric power sources.

Water Dependency Ratio (2008): This indicator represents the percentage of total renewable water resources originating outside the country.[2] This indicator may theoretically vary between 0 percent and 100 percent. A country with a dependency ratio equal to 0 percent does not receive any renewable water from neighboring countries. A country with a dependency ratio equal to 100 percent receives all its renewable water from upstream countries and does not produce any of its own. This indicator does not consider the possible allocation of water to downstream countries.

SOURCES

Population within 10km of the Coastal Zone (2010)

Center for International Earth Science Information Network (CIESIN), Columbia University. 2011. *National Aggregates of Geospatial Data: Population, Landscape and Climate Estimates*, vol. 3 (PLACE III), alpha version. Palisades, NY: CIESIN, Columbia University. Available at *http://sedac.ciesin.columbia.edu/place/*.

The Center for International Earth Science Information Network (CIESIN) at Columbia University calculated these numbers using the Global Rural Urban Mapping Project (GRUMP) population data set. The 2010 results represent projections rather than observations based on the most recent census data. Using GRUMP, CIESEN projected the population to 2005 based on sub-national rates of population change from HYDE (History Database of the Global Environment) and then extrapolated those rates to 2010, adjusting to equal UN estimates by country for 2010.

Percentage of Agricultural Land Dependent on Rainfall (2000)

Portmann, Felix T. (2010), Global estimation of monthly irrigated and rainfed crop areas on a 5 arc-minute grid, Dissertation zur Erlangung des Doktorgrades der Naturwissenschaften, vorgelegt beim Fachbereich 11 Geowissenschaften / Geographie der Johann Wolfgang Goethe – Universität in Frankfurt am Main, Frankfurt 2010.

Portmann, F.T., S. Siebert, and P. Döll (2010), MIRCA2000—Global monthly irrigated and rainfed crop areas around the year 2000: A new high-resolution data set for agricultural and hydrological modeling, Global Biogeochemical Cycles, 24, GB1011.

Electricity Production from Hydroelectric Sources (percent of total, 2008, 2009)

International Energy Agency. "Energy Statistics and Balances of Non-OECD Countries, Energy Statistics of OECD Countries, and Energy Balances of OECD Countries." Available at *http://data.worldbank.org/indicator/EG.ELC.HYRO.ZS*.

Water Dependency Ratio (2008)

Food and Agriculture Organization of the United Nations, Aquastat. Available at *http://www.fao.org/nr/water/aquastat/data/query/index.html (accessed April–June 2011)*.

Dependency Ratio Calculation Formula is available at *http://www.fao.org/DOCREP/005/Y4473E/y4473e07.htm*.

ENDNOTES

1 A 5 arc-minute grid is commonly referred to as a 10-kilometer grid.

2 "Renewable water resources are computed on the basis of the water cycle. . . . They represent the long-term average annual flow of rivers (surface water) and groundwater" (Source: FAO 2011).

Country	Population Living Within 10 km of a Coastline			Percentage of Agricultural Land Dependent on Rainfall		Water Dependency Ratio*		Electricity Production from Hydroelectric Sources (% of total)	
	Percent	Population	Year	Percent	Year	Percent	Year	Percent	Year
ASIA (EXCL. MIDDLE EAST)									
Armenia	N/A	N/A	2010	66	2000	11.7F	2008	31%	2008
Azerbaijan	…	…	2010	…	…	76.6F	2008	9%	2008
Bangladesh	9%	14,672,300	2010	57	2000	91.4F	2008	4%	2008
Bhutan	N/A	N/A	2010	64	2000	0F	2008	…	…
Brunei	70%	286,516	2010	94	2000	0.0	2008	…	…
China	6%	81,117,300	2010	49	2000	1.0	2008	17%	2008
East Timor	53%	626,358	2010	….	…	…	…	…	…
Georgia	…	…	2010	74	2000	8.2F	2008	85%	2008
India	5%	65,175,400	2010	63	2000	30.5F	2008	14%	2008
Indonesia	28%	65,327,100	2010	77	2000	0.0	2008	8%	2008
Japan	36%	46,132,800	2010	50	2000	0.0	2008	7%	2009
Kazakhstan	…	…	2010	89	2000	31.1F	2008	9%	2008
Korea, Dem People's Republic	22%	5,387,830	2010	55	2000	13.1F	2008	61%	2008
Korea, Rep	26%	12,599,200	2010	60	2000	6.9F	2008	1%	2009
Kyrgyzstan	N/A	N/A	2010	23	2000	0.0	2008	90%	2008
Lao People's Democratic Republic	N/A	N/A	2010	64	2000	42.9F	2008	…	…
Malaysia	32%	8,813,930	2010	91	2000	0F	2008	8%	2008
Maldives	…	…	2010	100	2000	0.0	2008	…	…
Mongolia	N/A	N/A	2010	81	2000	0F	2008	…	…
Myanmar	8%	4,252,780	2010	83	2000	14.1F	2008	61%	2008
Nepal	N/A	N/A	2010	70	2000	5.7F	2008	100%	2008
Pakistan	4%	6,548,580	2010	15	2000	76.1F	2008	30%	2008
Philippines	47%	44,119,800	2010	84	2000	0.0	2008	16%	2008
Singapore	91%	4,409,560	2010	100	2000	0F	2008	…	…
Sri Lanka	28%	5,713,970	2010	65	2000	0F	2008	45%	2008
Tajikistan	N/A	N/A	2010	35	2000	16.7F	2008	98%	2008
Thailand	8%	5,469,660	2010	65	2000	48.8F	2008	5%	2008
Turkmenistan	N/A	N/A	2010	25	2000	97.0F	2008	0%	2008
Uzbekistan	N/A	N/A	2010	23	2000	77.3F	2008	23%	2008
Viet Nam	16%	14,032,400	2010	55	2000	59.4	2008	36%	2008
EUROPE									
Albania	17%	536,435	2010	59	2000	35.4F	2008	100%	2008
Austria	N/A	N/A	2010	97	2000	29.21F	2008	60%	2009
Belarus	N/A	N/A	2010	98	2000	35.8F	2008	0%	2008
Belgium	4%	425,558	2010	98	2000	34.4F	2008	0%	2009
Bosnia and Herzegovina	0%	16,814	2010	>99.5	2000	5.3F	2008	34%	2008
Bulgaria	…	…	2010	98	2000	1.4F	2008	6%	2008
Croatia	25%	1,088,200	2010	>99.5	2000	64.2F	2008	43%	2008
Cyprus	48%	422,218	2010	13	2000	0F	2008	…	…
Czech Republic	N/A	N/A	2010	99	2000	0F	2008	3%	2009
Denmark	56%	3,084,190	2010	92	2000	0F	2008	0%	2009
Estonia	50%	669,682	2010	>99.5	2000	0.7F	2008	0%	2008
Finland	28%	1,485,090	2010	99	2000	2.7F	2008	18%	2009
France	12%	7,283,940	2010	90	2000	5.2F	2008	11%	2009
Germany	2%	1,813,060	2010	98	2000	30.5F	2008	3%	2009
Greece	60%	6,759,940	2010	62	2000	21.8F	2008	9%	2009
Hungary	N/A	N/A	2010	98	2000	94.2	2008	1%	2009
Iceland	80%	264,119	2010	…	2000	0.0	2008	73%	2009
Ireland	41%	1,901,100	2010	>99.5	2000	5.8	2008	3%	2009
Italy	29%	17,203,700	2010	71	2000	4.6	2008	17%	2009
Latvia	27%	604,941	2010	>99.5	2000	52.7F	2008	59%	2008
Lithuania	7%	230,608	2010	>99.5	2000	37.5F	2008	3%	2008
Luxembourg	N/A	N/A	2010	>99.5	2000	67.7F	2008	3%	2009
Macedonia	N/A	N/A	2010	89	2000	15.6F	2008	13%	2008
Malta	100%	409,999	2010	78	2000	0F	2008	…	…
Moldova	N/A	N/A	2010	86	2000	91.4F	2008	2%	2008
Netherlands	25%	4,206,400	2010	83	2000	87.9F	2008	0%	2009
Norway	44%	2,151,270	2010	94	2000	0F	2008	…	2009
Poland	3%	1,026,790	2010	99	2000	12.9F	2008	2%	2009
Portugal	38%	4,076,260	2010	73	2000	44.6F	2008	17%	2009
Romania	N/A	N/A	2010	96	2000	80.0F	2008	26%	2008
Russia	3%	4,499,270	2010	95	2000	4.3F	2008	16%	2008
San Marino	…	…	2010	100	2000	0.0	0	…	…
Serbia (NOTE A)	1%	65,073	2010	98	2000	0.0	0	26%	2008
Slovakia	N/A	N/A	2010	93	2000	74.8F	2008	17%	2009
Slovenia	4%	87,284	2010	95	2000	41.4F	2008	25%	2008
Spain	34%	15,364,400	2010	77	2000	0.2F	2008	9%	2009
Sweden	25%	2,281,180	2010	98	2000	1.7F	2008	49%	2009
Switzerland	N/A	N/A	2010	97	2000	24.4F	2008	53%	2009
Ukraine	N/A	N/A	2010	96	2000	61.9F	2008	6%	2008
United Kingdom	20%	12,564,000	2010	…	…	1.3F	2008	1%	2009
MIDDLE EAST AND N. AFRICA									
Afghanistan	N/A	N/A	2010	43	2000	15.3F	2008	…	…
Algeria	15%	5,489,500	2010	84	2000	3.6	2008	1%	2008
Bahrain	100%	807,131	2010	14	2000	96.6	2008	…	…
Egypt	10%	8,381,090	2010	17	2000	96.9	2008	11%	2008
Iran, Islamic Rep.	1%	848,730	2010	45	2000	6.6	2008	2%	2008
Iraq	0%	65,207	2010	1	2000	53.4F	2008	2%	2008
Israel	39%	2,813,750	2010	29	2000	57.8F	2008	0%	2008
Jordan	1%	85,118	2010	30	2000	27.2F	2008	0%	2008
Kuwait	67%	2,041,590	2010	8	2000	100.0	2008	…	…
Lebanon	54%	2,288,350	2010	50	2000	0.8	2008	4%	2008
Libya	35%	993,713	2010	53	2000	0F	2008	…	…
Morocco	22%	5,962	2010	78	2000	0F	2008	4%	2008
Occupied Palestinian Territory	32%	1,419,820	2010	77	2000	3.0	2008		…
Oman	54%	1,573,330	2010	4	2000	0F	2008	…	…
Qatar	66%	1,001,650	2010	0	2000	3.4	2008	…	…
Sao Tome and Principe	97%	160,659	2010	61	2000	0F	2008	…	…
Saudi Arabia	11%	2,950,090	2010	9	2000	0F	2008	…	…
Syrian Arab Republic	5%	1,072,750	2010	68	2000	72.4	2008	7%	2008
Tunisia	29%	3,041,050	2010	82	2000	8.7	2008	0%	2008
Turkey	7%	4,992,870	2010	83	2000	1.0	2008	18%	2009
United Arab Emirates	29%	1,388,200	2010	9	2000	0.0	2008		…
Yemen	8%	…	2010	62	2000	0F	2008	…	…

Country	Population Living Within 10 km of a Coastline			Percentage of Agricultural Land Dependent on Rainfall		Water Dependency Ratio*		Electricity Production from Hydroelectric Sources (% of total)	
	Percent	Population	Year	Percent	Year	Percent	Year	Percent	Year
SUB-SAHARAN AFRICA									
Angola	19%	3,612,580	2010	98	2000	0F	2008	96%	2008
Benin	18%	1,618,160	2010	>99.5	2000	61.0	2008	1%	2008
Botswana	N/A	N/A	2010	>99.5	2000	80.4	2008	...	...
Burkina Faso	N/A	N/A	2010	99	2000	0F	2008	...	...
Burundi	N/A	N/A	2010	98	2000	19.7F	2008	...	...
Cameroon	9%	1,833,940	2010	99	2000	4.3F	2008	76%	2008
Cape Verde	96%	491,323	2010	95	2000	0F	2008	...	...
Central African Republic	N/A	N/A	2010	>99.5	2000	2.3F	2008	...	...
Chad	N/A	N/A	2010	99	2000	65.1F	2008	...	...
Comoros	100%	688,448	2010	>99.5	2000	0F	2008	...	...
Congo, Rep.	19%	44,563	2010	99	2000	73.3F	2008	81%	2008
Côte d'Ivoire	9%	440,318	2010	99	2000	5.2F	2008	33%	2008
Democratic Republic of the Congo	...	...	2010	>99.5	2000	29.8F	2008	99%	2008
Djibouti	75%	661,260	2010	65	2000	0F	2008	...	...
Equatorial Guinea	35%	241,520	2010	100	2000	0F	2008	...	...
Eritrea	5%	274,792	2010	99	2000	55.5F	2008	...	...
Ethiopia	N/A	N/A	2010	95	2000	0F	2008	87%	2008
Gabon	52%	783,417	2010	96	2000	0F	2008	44%	2008
Gambia	54%	950,186	2010	99	2000	62.5F	2008	...	...
Ghana	17%	4,157,730	2010	>99.5	2000	43.0F	2008	74%	2008
Guinea	13%	1,319,770	2010	99	2000	0F	2008	...	...
Guinea-Bissau	41%	681,562	2010	98	2000	48.3F	2008	...	...
Kenya	4%	1,749,230	2010	98	2000	32.5F	2008	40%	2008
Lesotho	...	...	2010	>99.5	2000	0F	2008	...	...
Liberia	24%	993,713	2010	99	2000	13.7F	2008	...	...
Madagascar	12%	2,340,530	2010	54	2000	0F	2008	...	...
Malawi	N/A	N/A	2010	96	2000	6.5F	2008	...	...
Mali	N/A	N/A	2010	93	2000	40F	2008	...	...
Mauritania	14%	477,518	2010	92	2000	96.4F	2008	...	...
Mauritius	72%	937,786	2010	76	2000	0F	2008	...	...
Mozambique	17%	3,964,130	2010	99	2000	53.8	2008	100%	2008
Namibia	5%	102,747	2010	95	2000	65.2	2008	67%	2008
Niger	N/A	N/A	2010	99	2000	89.6F	2008	...	...
Nigeria	2%	3,746,900	2010	>99.5	2000	22.7F	2008	27%	2008
Rwanda	N/A	N/A	2010	>99.5	2000	0F	2008	...	...
Senegal	32%	4,149,760	2010	95	2000	33.5F	2008	10%	2008
Sierra Leone	25%	1,440,440	2010	94	2000	0F	2008	...	...
Somalia	23%	2,180,180	2010	62	2000	59.2	2008	...	...
South Africa	13%	6,747,140	2010	78	2000	10.4F	2008	0%	2008
Sudan (NOTE B)	1%	546,187	2010	89	2000	76.9F	2008	32%	2008
Swaziland	...	...	2010	75	2000	41.4F	2008	...	...
Tanzania	10%	4,282,640	2010	96	2000	12.7F	2008	60%	2008
Togo	18%	1,214,590	2010	>99.5	2000	21.7F	2008	74%	2008
Uganda	N/A	N/A	2010	>99.5	2000	40.9F	2008	...	...
Zambia	N/A	N/A	2010	95	2000	23.7F	2008	100%	2008
Zimbabwe	N/A	N/A	2010	91	2000	38.7	2008	53%	2008
NORTH AMERICA									
Canada	11%	3,655,960	2010	98	2000	1.7F	2008	59%	2009
United States	12%	39,061,300	2010	84	2000	8.2	2008	7%	2009
C. AMERICA & CARIBBEAN									
Antigua and Barbuda	100%	88,550	2010	96	2000	0F	2008	...	...
Bahamas	100%	345,317	2010	100	2000	0.0	2008	...	...
Barbados	100%	256,552	2010	93	2000	0F	2008	...	...
Belize	43%	133,325	2010	96	2000	13.8	2008	...	...
Costa Rica	9%	440,318	2010	74	2000	0F	2008	78%	2008
Cuba	32%	3,614,930	2010	64	2000	0F	2008	1%	2008
Dominica	100%	661,260	2010	100	2000	0.0	2008	...	...
Dominican Republic	33%	3,419,700	2010	76	2000	0.0	2008	11%	2008
El Salvador	10%	599,796	2010	94	2000	29.6F	2008	34%	2008
Grenada	100%	104,342	2010	99	2000	0.0	2008	...	...
Guatemala	3%	380,517	2010	91	2000	1.9	2008	43%	2008
Haiti	53%	5,440,420	2010	92	2000	7.2	2008	37%	2008
Honduras	8%	618,955	2010	90	2000	0.0	2008	35%	2008
Jamaica	52%	1,421,130	2010	87	2000	0.0	2008	2%	2008
Mexico	6%	6,322,190	2010	65	2000	10.5	2008	11%	2009
Nicaragua	6%	358,549	2010	92	2000	3.5	2008	16%	2008
Panama	45%	1,596,050	2010	90	2000	0.4	2008	62%	2008
Saint Kitts and Nevis	100%	52,368	2010	>99.5	2000	0F	2008	...	...
Saint Lucia	100%	173,942	2010	99	2000	0.0	2008	...	...
Saint Vincent and the Grenadines	100%	109,284	2010	100	2000	0.0	2008	...	...
Trinidad and Tobago	68%	911,026	2010	94	2000	0F	2008	...	...
SOUTH AMERICA									
Argentina	17%	6,906,740	2010	96	2000	66.1	2008	25%	2008
Bolivia	N/A	N/A	2010	95	2000	51.2	2008	37%	2008
Brazil	12%	23,971,200	2010	94	2000	34.1F	2008	80%	2008
Chile	17%	2,950,960	2010	48	2000	4.1	2008	41%	2008
Colombia	6%	2,771,330	2010	82	2000	0.9	2008	83%	2008
Ecuador	10%	1,317,520	2010	72	2000	0.0	2008	61%	2008
Guyana	23%	175,807	2010	23	2000	0.0	2008	...	...
Paraguay	N/A	N/A	2010	99	2000	72.0	2008	100%	2008
Peru	26%	7,602,110	2010	57	2000	15.5	2008	59%	2008
Suriname	55%	285,769	2010	16	2000	27.9	2008	...	...
Uruguay	43%	1,444,980	2010	72	2000	57.6	2008	51%	2008
Venezuela	22%	6,389,720	2010	72	2000	41.4	2008	73%	2008
OCEANIA									
Australia	36%	7,790,960	2010	90	2000	0F	2008	5%	2009
Fiji	59%	501,924	2010	98	2000	0F	2008	...	...
New Zealand	65%	2,790,580	2010	49	2000	0F	2008	56%	2009
Palau	...	...	2010	100	2000	0.0	0	...	...
Papua New Guinea	23%	1,612,080	2010	100	2000	0F	2008	...	...
Samoa	95%	109,284	2010	...	2000	0.0	0	...	...
Solomon Islands	84%	452,329	2010	100	2000	0F	2008	...	...
Tonga	100%	104,260	2010	100	2000	0.0	0	...	...
Vanuatu	94%	230,286	2010	100	2000	0.0	0	...	...

NOTE: If a country is not listed, no data for that country were available in any of these four categories.

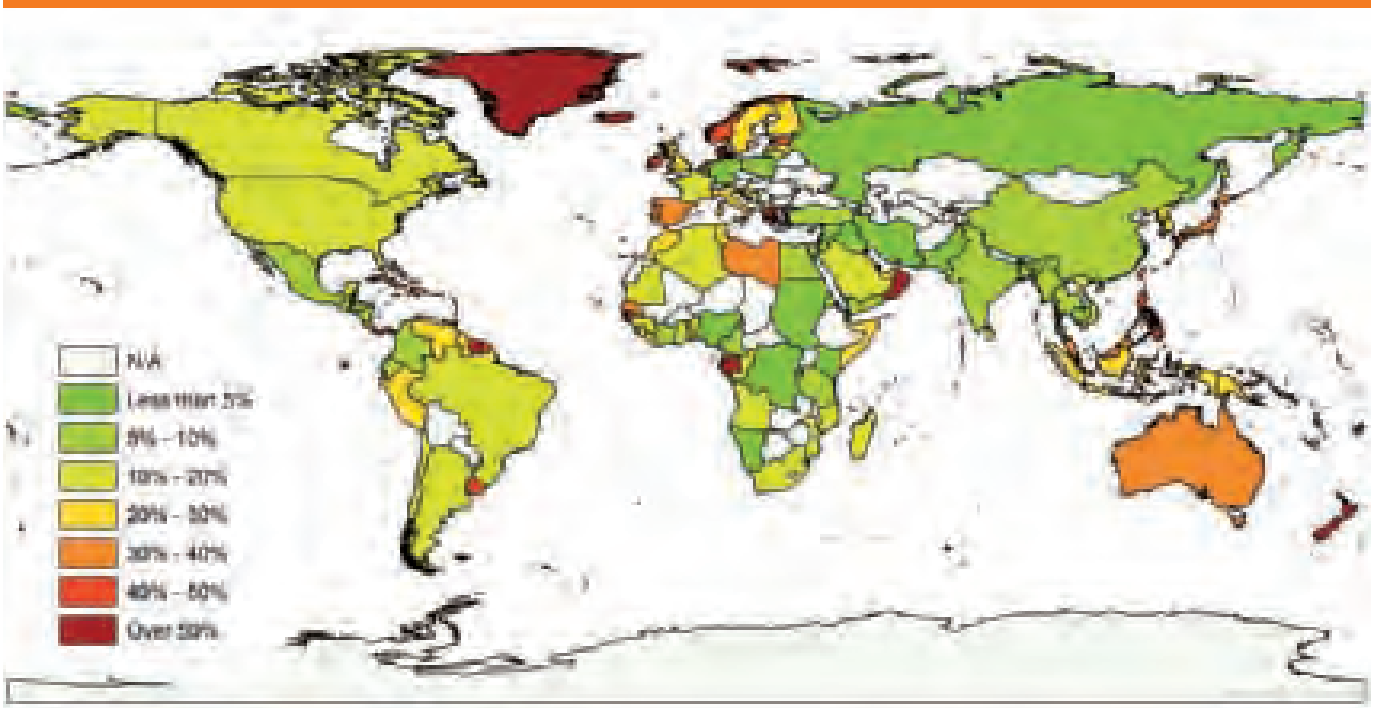
NOTE A: Data for Serbia may include the country of Montenegro (these countries were a single nation from 2003 to 2006). Separate data for Montenegro was not available.

NOTE B: These data include the country of South Sudan, which became independent in 2011.

*F=FAO estimate.

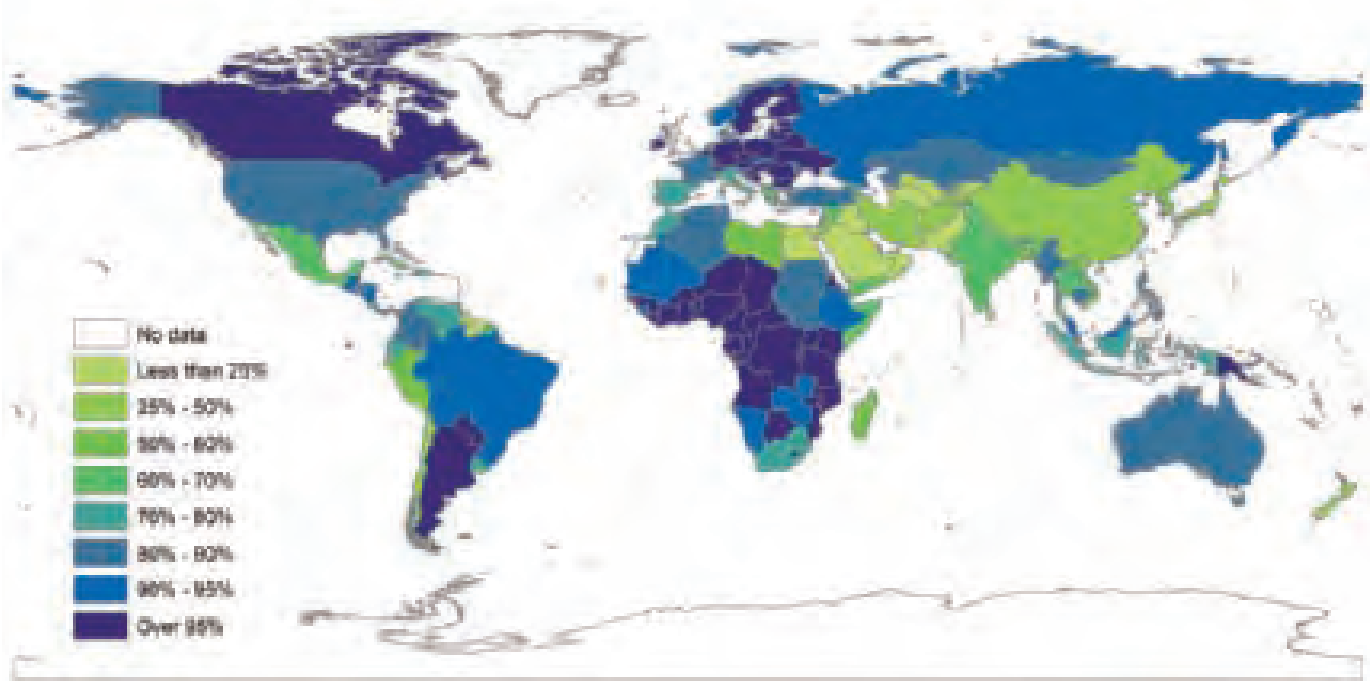
INDICATOR MAPS

Coastal Population



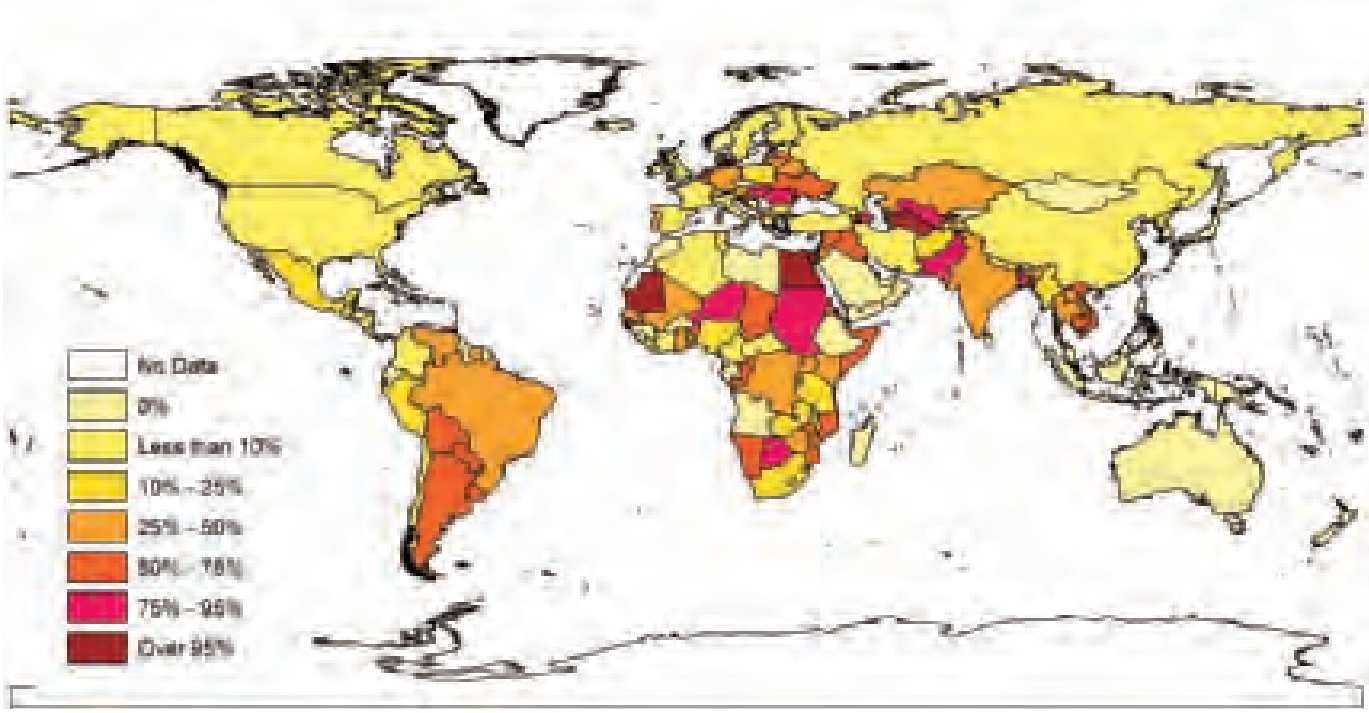
Percentage of a country's population living within 10 km (6.2 miles) of a coastline (2010).

Rain-Fed Agriculture



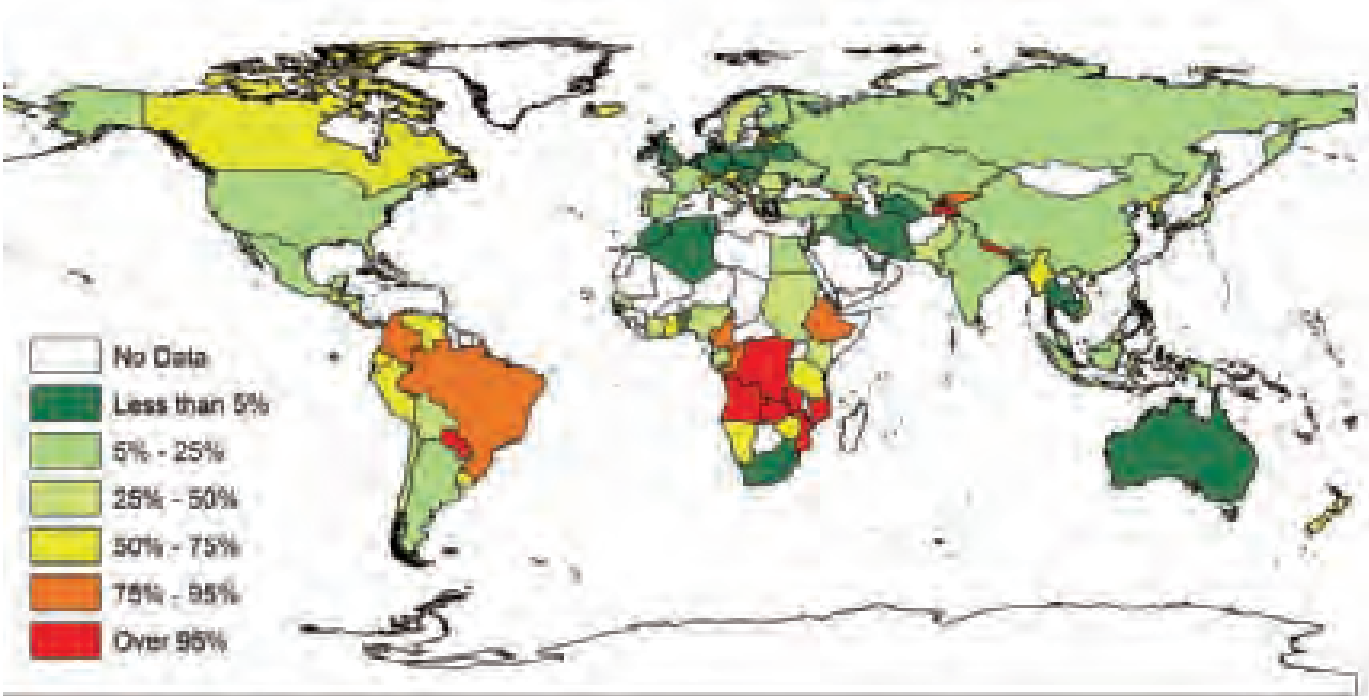
Percentage of a country's agricultural land area dependent on rainfall (non-irrigated land; 2000).

Water Dependency Ratio



Percentage of a country's total water resources that originate outside the country's national boundaries.

Hydroelectric Power



Percentage of the electricity generated in a country from hydroelectric sources (2008,2009).

ACKNOWLEDGMENTS

World Resources 2010–2011 is the thirteenth in a series that began in 1986. It has evolved from its initial objective as a comprehensive assessment of environment and development trends into a report that provides in-depth policy analysis of critical issues arising from human dependence and impact on the environment. In this edition, it has evolved yet again, adopting a new model for conducting research and for involving audiences from the very start, rather than waiting until publication. The role of the Internet and the range of communication tools that this report provides have assumed a far more important place than ever before.

The *World Resources Report* (WRR) continues to be the work of a special partnership with the United Nations Development Programme (UNDP), the United Nations Environment Programme (UNEP), the World Bank, and the World Resources Institute (WRI).

For this thirteenth edition in the *World Resources Series*, we again would like to express our gratitude to the Norwegian Ministry of Foreign Affairs. Its confidence in this new approach and its deep concern about climate change and adaptation have made possible this volume.

We are grateful as well to the Netherlands Ministry of Foreign Affairs, the Swedish International Development Cooperation Agency (SIDA), and the Office of International Development Assistance of the Ministry of Foreign Affairs of Denmark (Danida). They have been long-standing and dedicated supporters of the *World Resources Report*. We also would like to thank the Climate Investment Funds and its Pilot Program for Climate Resilience at the World Bank for their special contribution.

Individual Contributions

Embarking on a new model for the *World Resources Report* presented us with a number of unexpected challenges. We are grateful for the patience and for the advice of our partners as we worked though them. Peter Gilruth of UNEP; Warren Evans and Glenn-Marie Lange of the World Bank; and Bo Lim, Charles McNeill, and Jennifer Baumwoll of UNDP all have been extraordinary partners. Our special thanks to Ian Rector, who directs UNDP's African Adaptation Programme from Dakar, Senegal, and who has been a trusted adviser from the front lines.

This new model has also created logistical and management demands that have tested us all. We engaged more than 100 experts, officials, and practitioners in our research efforts, and their work has created an impressive body of material accessible to all on the WRR website (*www.worldresourcesreport.org*). Our contributors are listed at the front of this report.

In addition, we have subjected drafts of this report to broad-based and extensive reviews by all our partners, as well as government officials, researchers, and other practitioners. Their time, their concern and their insights have contributed immeasurably to this Report and there really is no way to adequately express our gratitude. On the following page, we list those who have helped guide and review our work.

We had able and generous assistance from several agencies and institutions as we sought information and data to help graphically and concisely illustrate important elements of emerging climate change impacts. Our thanks to Felix Portmann at the University of Frankfurt (Germany), Alex de Sherbinin at the Center for International Earth Science Information Network (CIESIN) at Columbia University, Giuseppe Molinaro at the University of Maryland, Ashbindu Singh at the UNEP's Regional Office for North America, and Lauren Monrone and Barbara Eubanks at the U.S. National Weather Service.

This report also benefited from the assistance of Greg Mock—no stranger to the *World Resources Series*—who brought a fresh eye to our work.

The staff at the World Resources Institute has been forthcoming with timely and sound advice, not to mention considerable flexibility as we worked though this new approach. To them we offer our sincere thanks: James Anderson, Athena Ballesteros, Steve Barker, Maggie Barron, Hyacinth Billings, Edward Cameron, Lalanath De Silva, Aarjan Dixit, Kathy Doucette, Joseph Foti, Peter Hazlewood, Norbert Henninger, Tim Herzog, Frances Irwin, Stacy Kotorac, Heather McGray, Robin Murphy, Jack Nelson, Michael Oko, Cliff Polycarp, Samantha Putt del Pino, Ashleigh Rich, Kim Thompson, David Tomberlin, Elsie Vélez-Whited, Bob Winterbottom, Lauren Withey, and Davida Wood. We also would like to acknowledge the early contributions of Mark Holmes.

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The WRR staff assembled for this edition has been extraordinarily dedicated and selfless with its time. Although it serves little purpose to detail the contributions of any one member, each of them—Kelly Levin, Polly Ghazi, and multi-talented Brian Lipinski—has made an indelible mark on this report and stepped up to meet challenges again and again.

Dan Tunstall, who is retiring from WRI this year, has been involved with every WRR since the first edition in 1986 when he was Director of Research. In formal and informal roles, he has been a part of every subsequent report. His long experience and his faith in the force of information are reflected in these reports.

Both Manish Bapna and Janet Ranganathan have juggled multiple demanding responsibilities at WRI and yet have found time and energy to give the WRR team judicious guidance and rigorous analysis because they care so much.

Finally, we would be negligent if we did not acknowledge the enormous debt we owe Jonathan Lash, who has been the President of the World Resources Institute for the last 18 years. This is the last of eight reports with his name on it, and it is the one that reflects his challenge to make the report more accessible and one that engages audiences earlier and more directly.

We have been blessed with a wealth of research from across the globe, thoughtful oversight and review, and partners fully committed to this project from the very start. We hope we have made full use of these resources. Any shortcomings are, of course, ours alone.

EXTERNAL REVIEWERS

We have been extraordinarily fortunate in the wide range of individuals who have served as reviewers of this report. Each has given of his or her time and expertise unselfishly even in the face of our changing schedule. We benefited as well from many at WRI who devoted many hours to this report; we acknowledge them elsewhere in the report. To all who gave us of their time, their advice and their experience, we offer our sincere thanks.

Mozaharul Alam, *United Nations Environment Programme*

Jennifer Baumwoll, *United Nations Development Programme*

Alessandra Casazza, *United Nations Development Programme*

Keith Cundale, *Africa Adaptation Programme*

Volodymyr Demkine, *United Nations Environment Programme*

Victoria Donaldson, *Africa Adaptation Programme*

Dr. Nathalie Doswald, *United Nations Environment Programme*

Eduardo Durand, General Director, *Department of Climate Change, Ministry of the Environment, Peru*

Munjural Hannan, *Government of Bangladesh*

Molly Hellmuth, *International Research Institute for Climate and Society/ Earth Institute, Columbia University*

Leo Horn-Phathanothai, *United Nations Development Programme*

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Sasha Lagrange, *Africa Adaptation Programme*

Luke Mawbey, *Africa Adaptation Programme*

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Ian Rector, *Africa Adaptation Programme*

Kanta Kumari Rigaud, *World Bank*

Shiv Someshwar, *International Research Institute for Climate and Society/ Earth Institute, Columbia University*

Pia Treichel, *United Nations Development Programme*

Dale Wilson, *Africa Adaptation Programme*

In June of 2011, we were able to present the report's preliminary findings and recommendations at a side event at the UNFCCC session in Bonn, Germany. A distinguished panel of government officials offered their assessments and were joined by senior representatives of our core partners. Their participation confirmed just how critical the issue of adaptation is becoming, and their comments gave added depth to our presentation. We owe much to them:

Pasha Carruthers, *Manager, Island Futures Division, National Environmental Service, Cook Islands*

Eduardo Durand, *General Director, Department of Climate Change, Ministry of the Environment, Peru*

David Payton, *Senior Advisor on Environment and Energy, UNDP*

Kanta Kumari Rigaud, *Lead Adaptation Specialist & Program Coordinator PPCR, Environment Department, The World Bank*

Mary Ann Lucille Sering, *Commissioner, Climate Change Commission, Philippines*

Armi Susandi, *Vice-Chair of Adaptation Working Group, Indonesia National Council on Climate Change*

Kaveh Zahedi, *Climate Change Coordinator UNEP*

ENDNOTES

GLOSSARY

1 IPCC 2001a.
2 IPCC 2001a.
3 IPCC 2001a.
4 IPCC 2001a.
5 IPCC 2001a.
6 IPCC 2001a.
7 IPCC 2001a.
8 IPCC 2001a.
9 IPCC 2001a.
10 Adapted from Brooks 2003.
11 NOAA 2008, accessed 2011.
12 IPCC 2001a.
13 IPCC 2001a.
14 IPCC 2001a.
15 GreenFacts 2011.
16 Smith 1996 as cited in Brooks 2003.
17 IPCC 2001a.
18 Stockholm Resilience Center n/d.
19 IPCC 2007d.
20 IPCC 2007d.

EXECUTIVE SUMMARY

1 The World Bank Group 2010a.
2 Fagre et al. 2009.
3 Foti et al. 2010.

CHAPTER 1

1 Meehl et al. 2007.
2 Magrin et al. 2007.
3 Magrin et al. 2007.
4 Lewis et al. 2011.
5 Xinhua 2011.
6 World Bank Group 2010a.
7 NASA 2011.
8 Hansen et al. 2006.
9 Hansen et al. 2004.
10 UNEP 2010.
11 UNEP 2010.
12 McGray et al. 2007.
13 OECD 2009.
14 OECD 2009.
15 With a few exceptions related to disaster risk reduction and spatial planning.
16 OECD 2009.
17 OECD 2009.
18 OECD 2009; With a few exceptions related to disaster risk reduction and spatial planning.
19 McKinsey & Company 2009; World Bank Group 2010b.
20 OECD 2009.
21 Spearman et al. 2011.
22 For example, Breit et al. 2003; Dessai et al. 2007; Gunderson et al. 1995; Hurrell et al. 1992; Ingraham 1994; Irwin et al. 2007; Kemp et al. 2005; National Research Council of the National Academies 2010b; Oglethorpe 2002; Prestre 2002; Swanson et al. 2009.
23 For example, Dessai et al. 2007; Dessai et al. 2010; Lempert et al. 2010; Lempert et al. 2000; Ranger et al. 2010a.
24 Adger et al. 2005; Lim et al. 2005; McGray et al. 2007; UNDP 2007/2008.
25 Leitzell 2011.
26 Magrin et al. 2007.
27 Magrin et al. 2007.
28 Magrin et al. 2007.
29 Cruz et al. 2007.
30 Boko et al. 2007.
31 Cruz et al. 2007.
32 Magrin et al. 2007.

CHAPTER 2

1 Lempert, et al. 2003; Meuleman and Veld 2009; Princen 2009 as cited in National Research Council of the National Academies 2010a.
2 Hellmuth et al. 2007.
3 CCCD 2009; Hellmuth et al. 2007.
4 CCCD 2009.
5 Cruz et al. 2007.
6 Met Office 2010; Stern 2006.
7 Ranger et al. 2010b.
8 Ranger et al. 2010b.
9 Folland et al. 2001; Solomon et al. 2007.
10 IPCC 2001a.
11 Kimble et al. 2009.
12 IPCC 2001a.
13 Karl et al. 1999.
14 IPCC 2007b.
15 Trenberth et al. 2007.
16 IPCC 2007e.
17 Meehl et al. 2007.
18 IPCC 2001a.
19 Boko et al. 2007.
20 Margulis et al. 2010.
21 Dasgupta et al. 2007.
22 Hansen 2006.
23 Brown et al. 2008.

24 Solomon et al. 2007.
25 Cooley et al. 2009.
26 UNFCCC 2005.
27 Levin et al. 2006, 2007, 2008, 2009.
28 Howden et al. 2008.
29 IPCC 2007e.
30 IPCC 2007e.
31 IPCC 2000.
32 Dessai et al. 2010.
33 This is in part due to a sea ice-temperature feedback. See Screen et al. 2010.
34 UNDP 2007/2008.
35 IPCC 2007b.
36 UNFCCC 2008.
37 Stern 2006; UNDP 2007/2008.
38 UNDP 2007/2008.
39 Wang et al. 2010.
40 Babugura, et al. 2010.
41 IPCC 2007e.
42 Cutter 2009.
43 Schneider et al. 2007.
44 Christoplos 2009.
45 UNFCCC 2008.
46 Christoplos 2009.
47 Stern 2006; UNDP 2007/2008.
48 It should be noted that there are always exceptions. While there is a strong correlation between poverty and vulnerability to extremes, some of the poorest populations may have the ability to withstand shocks better than others. For example, some residents of poor communities have participated in labor markets and thus could be better able to change livelihoods (see Dixit et al. 2004).
49 UNDP 2007/2008.
50 Stern 2006.
51 UNDP 2007/2008.
52 Christoplos 2009. On the other hand, if populations are not exposed often to events, their capacity to adapt may be weakened. "Concrete dams may be more efficient than locally constructed brushwood dams but, because they require little routine re-building, local communities often do not have the capacity to repair them. Capacity is only maintained where it is in constant use" (Dixit et al. 2004).
53 IPCC 2009.
54 Dercon 2005, as cited in UNDP 2007/2008.
55 USAID 2007.
56 Kundzewicz et al. 2007.
57 UNHCR 2010.
58 UNDP 1997.
59 This box draws on Lempert et al. 2010.
60 It may also prove less expensive to address some impacts preemptively. As cited by Gupta et al. 2008, the costs of Hurricane Katrina would have been US$76 billion to $176 billion less had levees been constructed in advance. However, if the climate impact does not manifest itself as projected, such early interventions could prove more expensive.
61 IPCC 2009.
62 Sharma 2007.
63 CCSP 2008.
64 Ranger et al. 2010b.
65 Hellmuth 2010.
66 National Research Council of the National Academies 2009.
67 National Research Council of the National Academies 2010a.
68 Ranger 2010.

CHAPTER 3

1 Foti et al. 2008.
2 Warner et al. 2002.
3 Foti et al. 2010.
4 UNDP 2009.
5 These are: 1. Identify the poor and establish thresholds for enhanced access; 2. Use the right form to communicate; 3. Use the right channels to communicate; 4. Reduce costs; 5. Defend the organizations and individuals that promote access; 6. Clarify resource-related rights and remove legal barriers of standing and evidence; 7. Build capacity and raise awareness; 8. Make the voice of the poor influential.
6 Foti et al. 2010.
7 Foti et al. 2010.
8 UNDP 2008.
9 National Research Council 2008.
10 Foti et al. 2008.
11 Foti et al. 2010.
12 Warner et al. 2002.
13 National Research Council of the National Academies 2008.
14 National Research Council of the National Academies 2008.
15 Canales 2010.
16 Canales 2010.
17 Suarez et al. 2010.
18 Someshwar 2010.
19 Herbertson et al. 2009.
20 Hellmuth 2010.
21 Warner et al. 2002.
22 Adger 2010.
23 Hellmuth et al. 2010.
24 Someshwar et al. 2010.
25 Spearman et al. 2011.
26 Mumbi 2010.
27 Mumbi 2010.
28 Matambo et al. 2010a.

CHAPTER 4

1 Rowley 2007.
2 Overpeck et al. 2011 project that by 2030, 350 terabytes of climate data will be available to scientists and decision makers. A terabyte is 1,000 gigabytes.
3 UK DFID 2004.
4 Bueti and Faulkner 2010.
5 The World Weather Watch at the core of WMO's programs. Established in 1963, its purpose is "to make available meteorological and related geophysical information needed to provide efficient services in all countries."
6 Washington, Harrison, and Conway 2004.
7 Washington, Harrison, and Conway 2004.
8 Bueti and Faulkner 2010.
9 Canales 2010.
10 Street 2010.
11 Benson, Twigg, and Rossett 2007. Material throughout this section draws on McGray 2011 and WRI 2009.
12 IPCC 2010.
13 For examples, see UNISDR 2008.
14 Benson, Twigg, and Rossett 2007.
15 Liverman 2010.
16 Hellmuth et al. 2007.
17 National Research Council of the National Academies 2009.
18 *The Economist* 2011.
19 Hellmuth 2010.
20 Hellmuth et al. 2010.
21 Hellmuth et al. 2010.
22 UK DFID 2010.
23 Luxbacher and Goodland 2010.
24 Bueti and Faulkner 2010.
25 Hellmuth et al. 2007.
26 National Research Council of the National Academies 2009; Someshwar 2010.
27 Ranger et al. 2010.
28 Adger et al. 2008; IPCC 2007b.
29 Fischhoff et al. 1981.
30 Fischhoff et al. 1981.
31 Someshwar 2010; Street 2010.
32 Ranger et al. 2010.
33 Ranger et al. 2010.
34 This definition has been expanded beyond the definition of ecosystem threshold; see Fagre et al. 2009.
35 Fagre et al. 2009.
36 Recent estimates suggest that with 20 percent of the Amazon deforested, coupled with climate impacts and fire, significant losses of rainforest will ensue by 2025 as the ecosystem switches to a different state. With this rate of deforestation, in eastern Amazonia only 26 percent of the rainforest would be left, and in the southern Amazon, there would be a 38 percent increase in savanna ecosystems. See Scholz and Vergara 2010.
37 Kibiiy and Rao 2003.
38 Liverman 2010.
39 Hellmuth et al. 2010.
40 Someshwar, Boer, and Conrad 2010.
41 Bueti and Faulkner 2010.
42 Bueti and Faulkner 2010.
43 Bueti and Faulkner 2010.
44 Govender 2010; Group on Earth Observations 2011.
45 Padgett 2010b.
46 Matambo and Shrestha 2010.
47 Zook et al. 2010.
48 Google Map Maker can be accessed at *http://www.google.com/mapmaker*.
49 Zook et al. 2010.
50 Fagre et al. 2009.
51 Matambo and Shrestha 2010.
52 Presentation by Margaret Hammond, Ireland Environmental Protection Agency, at World Resources Institute, Washington, DC, September 16, 2010.
53 Suarez, Benn, and Macklin 2010.
54 Mumbi 2010.
55 Mumbi 2010.
56 Someshwar, Boer, and Conrad 2010.
57 Mumbi 2010.
58 IEPAS 2010.
59 Mumbi 2010.
60 Luxbacher et al. 2010.
61 Robinson 2007.
62 Rodriguez et al. 2009.
63 Basher 2006.
64 Liverman 2010.
65 IPCC 2009.
66 Thomalla et al. 2009.
67 Matambo et al. 2010b.

CHAPTER 5

1 This is based on an email discussion held on UNDP's EENet, in which many of the country representatives who responded reported coordination efforts to be incomplete or absent entirely.
2 Hall et al. 2001, March et al. 1989.
3 Ranger et al. 2010b.
4 UNFCCC 2008.
5 This box draws upon Bapna et al. 2009 and IISD Reporting Services 2011.
6 Swanson et al. 2009.
7 UNDP 2010.

8 Lim et al. 2010.
9 Hove et al. 2010.
10 Personal communications with UNDP-AAP Programme Manager and UNDP-AAP Senior Adviser, May 23, 2011, and June 21 and 23, 2011.
11 IPCC 2009.
12 Luxbacher et al. 2010a.
13 Govender 2010.
14 Govender 2010.
15 Luxbacher et al. 2010a.
16 It should be noted that these conditions enabled the use of the tool, embrace of policy measures did not always follow because of scant financial and technical resources.
17 CCCD 2009. and Mehra 2010.
18 OECD 2009.
19 Mehra 2010.
20 National Research Council of the National Academies 2010a.
21 World Bank 2004.
22 According to the International Monetary Fund's World Economic Outlook Database, Kiribati's GDP in 2008 was US$135 million.
23 World Bank 2011a.
24 Republic of Kiribati 2010.
25 Republic of Kiribati 2010.
26 Pittock et al. 2010.
27 Wang et al. 2010.
28 For example, Sri Lanka has established a labor productivity award, given by the President, to local-level institutions. The Philippines has established a Millennium Development Goal award at the local level for the best-performing authorities. Civil servants in India can be chosen to be included in the Indian Administrative Service, a strategic position of empowerment.
29 Petersen et al. 2010.
30 Lim et al. 2010.
31 Brown 2011.
32 Pittock et al. 2010.
33 Swanson et al. 2010.
34 Department of Transport, Republic of South Africa 2009.
35 Zambrano-Barragán 2010.
36 Sprinz 2010.
37 Luxbacher et al. 2010a.
38 Lim et al. 2010.
39 Agrawal 2008.
40 Lobo 2010.
41 Millennium Ecosystem Assessment 2005.
42 Hellmuth et al. 2007.
43 Liverman 2010.
44 Liverman 2010.
45 Levin 2009.
46 Petersen et al. 2010.

CHAPTER 6

1 As defined by the National Research Council of the National Academies (2010a), decision tools are "structured methods for evaluating the results of different decisions and provide a way of assessing the impacts, costs, and benefits for different decisions and strategies."
2 Petersen et al. 2010.
3 A World Bank study on the "Economics of Adaptation to Climate Change" (2010a), estimates that adapting to a 2-degree Celsius world will cost $70 billion to $100 billion a year by 2050.
4 Berger et al. 2010.
5 WRI 2009.
6 Ranger et al. 2010b.
7 Ranger et al. 2010b.
8 Luxbacher et al. 2010a.
9 Ranger et al. 2010b.
10 UNDP 2011.
11 Ranger et al. 2010b.
12 Ranger et al. 2010b.
13 Ranger et al. 2010b.
14 Benson et al. 2007; Ranger et al. 2010b.
15 Benson et al. 2007.
16 WMO 2011.
17 Ranger et al. 2010b.
18 Bueti et al. 2010.
19 Benson et al. 2007.
20 Benson et al. 2007.
21 Benson et al. 2007.
22 Benson et al. 2007.
23 Petersen et al. 2010.
24 Carter et al. 2007.
25 Garg et al. 2007.
26 Carter et al. 2007.
27 Someshwar et al. 2010.

CHAPTER 7

1 UNFCCC 2010.
2 Ikram 2010.
3 Begashaw 2010; Gwage 2010; Lim et al. 2010; Lohani 2010; Muller 2010; Muyungi 2010; Ottichilo 2010; Siegel 2010.
4 CCCD 2009.
5 CCCD 2009; Lim et al. 2010.
6 WRI 2010a.
7 CCCD 2009; Lim et al. 2010.
8 The Paris Declaration on Aid Effectiveness of 2005 emphasized five key principles of joint progress on aid effectiveness: ownership,

alignment, harmonization, results, and mutual accountability. The Accra Agenda for Action, a follow-up agreement from 2008, added the principles of predictability, a preference for country systems, conditionality, and relaxing economic restrictions.

9 Christoplos et al. 2009.
10 Maclean et al. 2008.
11 Dixit 2010.
12 Dixit 2010.
13 Dixit 2010.
14 UNFCCC 2008.
15 UNEP/UNISDR 2009.
16 Ranger 2010.
17 To be effective, underlying data for the index must be highly correlated with the loss, be based on sufficient historical data, and be adjusted for recent trends (see Barrett et al. 2007).
18 Spiegel 2010.
19 Spiegel 2010.
20 Ranger 2010.
21 Arnold 2008.
22 Ranger 2010.
23 UNDP 2007/2008.
24 UNDP 2007/2008.
25 UNDP 2007/2008.
26 Seymour 2010.
27 Locatelli et al. 2010.
28 Seymour 2010.
29 Matambo et al. 2010b.
30 Hove et al. 2010.
31 Peterson et al. 2010.
32 Luxbacher et al. 2010a.
33 Locatelli et al. 2010; Vignola et al. 2009.
34 Colls et al. 2009.
35 Locatelli et al. 2010.
36 Cruz et al. 2007.
37 Millennium Ecosystem Assessment 2005.
38 Also, as a result of gender inequality with regard to landowning roles and rights to resources, women in many societies are often more vulnerable to the degradation of natural resources (Millennium Ecosystem Assessment 2005).
39 Jouanno et al. 2011.
40 Millennium Ecosystem Assessment 2005; Sudmeier-Rieux et al. 2006.
41 This box is adapted from Hanson et al. 2008.
42 Sudmeier-Rieux et al. 2006.
43 Sudmeier-Rieux et al. 2006.
44 Ranganathan et al. 2010.
45 Hanson et al. 2008; Ranganathan et al. 2008.
46 Ranganathan et al. 2010.
47 Adger 2003; Dekker and Uslaner 2001.
48 Putnam 1995; Woolcock and Narayan 2000.
49 Adger 2001.
50 Adger 2001.
51 World Bank 2011b.
52 Malena et al. 2004.
53 UNDP 2007/2008.

CHAPTER 8

1 While no recent extreme event can directly be attributable to climate change, most are indeed consistent with a warming world.
2 Hansen et al. 2006.
3 Hansen et al. 2004
4 Brown et al. 2008.
5 IPCC 2007b.
6 Solomon et al. 2007.
7 Adger et al. 2008; IPCC 2007b.
8 Levin et al. 2006, 2007, 2008, 2009.
9 There are key exceptions to this. See for example, UNDP's Africa Adaptation Programme.
10 Adger et al. 2008; IPCC 2007b.
11 Dessai et al. 2010; Ranger 2010.
12 Burke et al. 2011.
13 Fagre et al. 2009.
14 Fagre et al. 2009.
15 Fischlin et al. 2007; O'Neill et al. 2002; Parmesan et al. 2003.
16 Fagre et al. 2009.
17 Stern 2006.
18 DeSalle et al. 2008.
19 National Water Development Agency n.d.
20 Spearman et al. 2011.
21 World Bank Group 2010b.
22 Foti et al. 2010.

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INDEX

Boxes, figures, and tables are indicated by *b*, *f*, and *t* following page numbers.

D

E

F

G

H

I

J

K

L

M

N

O

P

Q

R

S

T

U

V

W

Y

Z

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ADAPTATION TO ACCOMMODATE CLIMATE CHANGE WILL FRAME THE FUTURE for countries and communities across the globe. Responding to climate impacts as diverse as altered rainfall patterns, more frequent extreme weather events, and rising sea levels will challenge decision makers at every level of government and in every sector of the economy. What steps should be taken to protect vital infrastructure, such as roads, dams, and factories, or to ensure the safety of housing stocks, both existing and yet to be built? What policies should be adopted or investments made to help agriculture adapt to new rainfall and temperature regimes and to secure local food supplies? How should valuable ecosystems like forests or coral reefs be managed to maintain the vital services they render and livelihoods they support? How can we ensure that the unique challenges faced by the most vulnerable and disadvantaged people are not overlooked or ignored?

The decisions made to address these questions will influence the path of growth and development in communities and nations for years to come, yet such decisions are rarely straightforward, and are often contentious. This difficulty is compounded by the complexity of natural systems and national economies, by the uncertainties of predicting climate impacts, and by the diversity of stakeholders that these decisions must serve. It is not surprising, then, that many governments are unsure how to approach adaptation-related decisions in a manner that meets their environmental, economic, and social challenges efficiently and fairly.

World Resources 2010–2011 addresses the difficulty of—and pressing need for—adaptation decision making. It examines current decision-making practices, acknowledging the inherent challenge in anticipating and responding to both short-term and long-term climate change risks in national policies and plans. This report then focuses on how national governments, particularly those in developing countries, can adapt to climate change by integrating climate risks into their current practices so as to increase the resilience of their communities and ecosystems.

World Resources 2010–2011 is available electronically as a PDF document on the WRR website; also available is the complete body of research commissioned for this report. For more information, please go to www.worldresourcesreport.org.

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