World Resources 2010 Framing Paper: Decision Making in a Changing Climate

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OVERVIEW

As a result of the unprecedented rate of human-induced climate change, there is now widespread consensus on the need for adaptation efforts to contend with current and anticipated harm associated with climate impacts on people and ecosystems. While mitigation activities help curb greenhouse gas emissions, adaptation efforts bolster the resilience of human-built and natural environments.

Yet integrating current and future risks posed by climate change into planning and policy processes poses significant challenges to decision makers:

- How are policy makers in the western Sahel to plan for water-intensive economic activities, when some models predict a significant drying and others predict more precipitation and expanding vegetation?
- How should an energy planner in the Andes consider future glacial meltwater loss when siting hydroelectric plants?
- How should urban centers located on major deltas prepare for eventual sea level rise and saltwater intrusion to aquifers?
- How should ecosystem managers prioritize different management strategies, given changes in species migration, predator-prey relationships, and ecosystem composition due to altered precipitation and temperature regimes?
- If climate change is to prolong drought episodes in some regions, what options do water planning ministries have to prepare for these shocks?

Decision makers will have to contend with surprises associated with climate change, as well as future change. Some of these future changes are uncertain and will only manifest themselves in decades to come but require early planning. Yet human society has historically found proactive decision making

challenging. Our decision-making processes are often slow to react to, learn from, and foresee change. Existing planning processes tend to prioritize current risks, even if efforts could be better spent towards mitigating future risks. Those most vulnerable have the fewest resources to recover from today's climate impacts – as a changing climate also requires dealing with existing risks, adapting now and over the near-term – let alone contend with unpredictable future impacts.

And even if resources were available, short-term memory and attention spans are finite, leading to a failed recognition of incremental change. We tend to discount the future, and, therefore, information pertaining to future costs and benefits are often not considered in the same manner as those in the near term.

Additionally, change is difficult to realize, even if decision makers are committed to achieving it. Historical problem-solving attempts can have lasting implications for current efforts. Also, information generation and governance has become increasingly decentralized and fragmented, challenging decision makers' abilities to gather relevant data and knowledge and coordinate on problem solving. This is problematic because planning and policy objectives, as well as sustainable and inclusive growth and development goals, are unlikely to be achieved if future climate risks are not also taken into account in the near term.

How is a decision maker with limited resources to contend with pressing needs today while preparing for surprises and eventual impacts, some of which may be uncertain or only manifest themselves in future decades? *World Resources 2010*, a joint publication of the UN Development Programme, UN Environment Programme, the World Bank, and World Resources Institute, will explore the topic of "decision making in a changing climate." The Report will shed light upon how decision-making processes – for example, in integrated water resource planning, energy sector planning, ecosystem management, municipal development plans, and others (see Table 1) – can be designed to both respond to current climate risks and prepare for future risk. It will examine the barriers in doing so as well. The Report will focus on national-level planning and policymaking processes in developing countries, and implications for development assistance.

Table 1: Sectoral Decision-Making Processes that Will Need to Incorporate Short- and Long-Term Climate Risks

Sector	Example of Decision-Making Process
Agriculture	National Agriculture Plan Crop Management Plan
Energy	National Energy Policy/Strategy
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
Urban Planning/ Infrastructure	National Transportation Plan Road Maintenance Finance Plan National Highway Plan
Water	National Water Policy Integrated Water Resource Management Plan

World Resources 2010 will actively engage adaptation experts and decision makers throughout the course of its research activities. The Report's lessons will be gathered via case studies, papers

commissioned from thought leaders, supplemental research, and in-person and online meetings exploring relevant policy questions. In addition, the Report will build upon relevant research from academic and gray literature and translate findings to the Report's target audience: national-level decision makers and civil society organizations in developing countries. A synthesis document will be produced, providing guidance for how national-level plans and policies can be designed to integrate current and future risks and increase the resilience of communities and ecosystems in a changing climate.

INTRODUCTION TO DECISION MAKING IN A CHANGING CLIMATE

Even if atmospheric concentrations of greenhouse gases were stabilized at relatively low levels, communities and ecosystems across the globe will still face substantial impacts from climate change that demand adaptation measures. While scientists have dramatically improved the understanding of climate impacts, climate change risks have yet to become systematically integrated into policy making, planning, practices and investments. Consideration of climate change and its risks in decision-making processes is necessary to mitigate the impact on human well-being, species diversity, and critical functions performed by physical, hydrological and biological systems. Moreover, if plans and policies do not incorporate climate risks, expenditures may be less effective, investments may become obsolete, and goals may not be met. Opportunities to deal with conflicts and synergies may be lost or less effective. Also, some of the potential benefits to mainstreaming climate risks into policymaking and planning could be lost. Interventions that bolster resilience of ecosystems in a changing climate can increase human well-being. For example, maintenance of forests in montane areas can help prevent soil erosion and reduce risks of mudslides if the area is at risk of increased precipitation. Protection of coral reefs can ensure that fish are available for local consumption and livelihoods. Preservation of wetlands can provide buffers to storm surges.

Yet, trends are emerging that would be daunting to even the most seasoned decision maker committed to advancing adaptation interventions. The Earth's global surface temperature has warmed 0.8°C in the last century, having increased 0.2°C per decade over the last thirty years (Hansen et al. 2006). Daily minimum temperatures have increased at a faster rate than maximum temperatures, with implications for frost days and growing seasons (Brown et al. 2008). Sea level rise has accelerated as a result of seawater expansion due to warming ocean temperatures and the loss of glaciers and ice caps (Solomon et al. 2007). The oceans have become 30% more acidic since pre-industrial levels (Solomon et al. 2007) with profound implications for marine ecosystems and for human communities that rely upon their services.

If these trends were simply to increase linearly, planners and policymakers would have no easy task. Yet recent science suggests that many impacts are not advancing linearly (WRI 2006, 2007, 2008, 2009a). Climate change impacts can compound those brought by other stressors. Ecosystem and human responses to climate change will not be easy to anticipate. Political conflict may become more likely as shared resources become more threatened. Today's fragile states may become more chaotic, with implications for global security. Some communities may be forced to migrate if adaptation *in situ* becomes impossible. Accordingly, climate impacts borne by one community quickly manifest themselves into regional – and even global –

impacts, as human and non-human populations migrate and occupy new regions where and when possible.

For some problem solving, these complexities may not present themselves as a challenge. The problem solver would simply resolve critical uncertainties and hurdles before offering prescriptions. Yet, the underlying nature of climate change poses significant challenges to decision making. Policy makers and planners responding do not have the luxury of time. There are some changes – the loss of ice sheets, unique cultures, species diversity, and functions of biological, physical and hydrological systems – that will be irreversible, even within a generational timeframe.

ATTRIBUTES OF A CHANGING CLIMATE THAT POSE CHALLENGES TO DECISION MAKING

Several dimensions of human-induced climate change perturbations pose significant challenges to integrating climate risks into existing planning and policymaking processes. First, the *change in the mean state of the climate system and its variability* can present altered patterns in extreme events and novel situations and environments, heretofore inexperienced. Second, the ways in which climate change will impact some communities and ecosystems remain unknown and, therefore, considerable *uncertainty* is associated with those impacts and associated risks. Third, for some impacts, climate change poses challenges due to the *temporal and spatial scales* of impacts. There can be a time lag of impacts, with impacts only manifesting themselves in future years but demanding upfront measures. And, at the same time, some impacts can be borne at unprecedented rates. Climate change also presents hurdles to decision making as a result of the significant spatial scale that impacts present themselves across. Lastly, there are unexpected *surprises* associated with climate change that will not be possible to anticipate. Perhaps most challenging, all of these attributes of the climate change problem can be present at the same time in any given planning or policymaking process.

Changes in the Mean State of the Climate System and its Variability

A changing climate is projected to bring significant alterations in the mean state of the climate and its variability. For example, models project that we may be entering an El Niño-like phase, with sea surface temperatures in some regions warming more than in others and more intense rainfall events interrupting longer dry periods, resulting in greater risks of floods (Meehl et al. 2007). Changes to the Asian monsoon are projected to result in an increase in precipitation by the end of the 21st century in the tropics, while the Sahel is to witness decreased precipitation in the northern summer as a result of changes in the West African monsoon (Meehl et al. 2007). Additionally, more extreme heat episodes are expected. As a result of warming, the rate of glacial volume loss is likely to increase over the next few decades (Meehl et al. 2007).

While directional changes in the average state of hydrological, physical and ecological systems will persist for decades or longer, changes in variability may alter the rate, timing, and directionality of natural cycles and extreme events. Changes in the mean climate state (see Figure 1) could include altered precipitation, changes in ecosystem dynamics, sea level rise, glacial melt, warming of sea surface temperatures, and others. Changes in variability (see Figure 2) could include increased

frequency of fires and seasonal shifts in hurricanes. Some changes in the mean state of the climate system and its variability are predictable; others may not be.

Figure 1: Changes in the Mean State of the Climate System

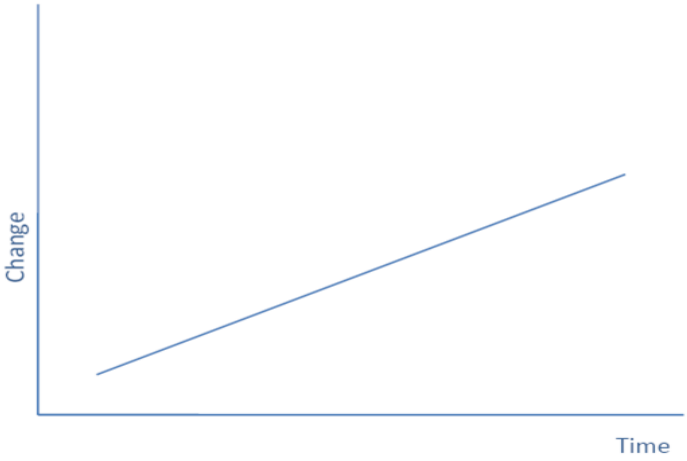
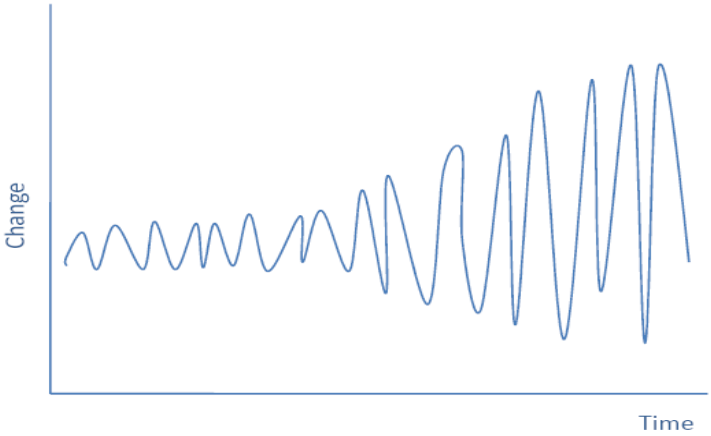


Figure 2: Changes in the Variability of the Climate System



Contending with Changes in the Mean State of the Climate System and its Variability

How are planning processes to prepare for a change in mean climate that alters current practices? For example, how is the decision maker responsible for coastal planning to contend with irreversible coral bleaching due to increased sea surface temperatures, which is driving away fish populations that communities rely upon? How is a water planning ministry to prepare for localized deglaciation due to warming? How should an agricultural minister prepare for projected declines in certain cereal species productivity, some of which may be the basis for its country's export market, because of prolonged drought?

And how are planning processes to prepare for changes in the frequency and intensity of climate impacts as a result of climate variability and extremes? How is the health minister to plan for more common heat stress and heat wave events? How is the urban planner to prepare for flash floods resulting from intensified downpours that are projected to occur twice as often as they used to? What resources are needed for the forest ministry to prepare for more frequent forest fire events and pest outbreaks?

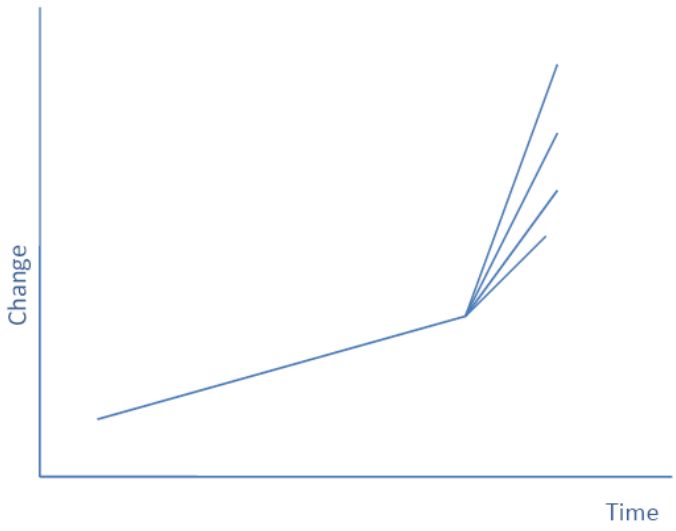
Uncertainty

While, to be sure, there is now significant consensus with regard to the role human activities play in climate change and the directionality of many projected changes, there is still uncertainty (see Figure 3) with regard to the rate and magnitude of the impacts across the globe. Uncertainty stems from a lack of knowledge about key factors, such as: the drivers of change today and in the future; the response of the climate system; the way impacts will manifest themselves across regions; interactions with climate change and other drivers of change; and others. For example, emissions growth will depend on population growth, economic growth, technological development, and energy use, as well as the rate of mitigation policies and behavioral change (Intergovernmental Panel on Climate Change 2000). Yet emissions and, in turn, atmospheric concentrations of greenhouse gases do not correspond to temperature increases easily. Atmospheric concentrations of greenhouse gases are associated probabilistically with temperature; there is no linear relationship, and, thus, there is only a range of temperature outcomes for every stabilization scenario. As a result, there is an array of climatic impacts that could play out in biological, hydrological, and physical systems and, in turn, socio-political and economic systems.

Each of these impacts has its own associated uncertainties. And even if global average impacts could be forecasted, there is significant diversity with regard to how impacts are distributed across the globe, with some regions impacted far more than others. Most significantly, projections often lack resolution on scales that matter to decision makers. While models now depict some changes on a local level, the majority of forecasts focus on a larger regional or global scale. Therefore, while a region might have an understanding of large-scale patterns of ecosystem change as a result of warming and altered precipitation, there may be little information on future impacts to a particular forest, for example, in that region. Also, uncertainties will be compounded by both low probability, high impact events (e.g. rapid glacial loss, permafrost loss, tipping of tropical forests, methane clathrate disintegration) and surprises, which may be omitted from forecasts altogether.

The implications of uncertainty for decision making are significant. Uncertainty is often used as an excuse for inaction. It can paralyze decision makers and/or bias their judgment. Often, we can "get by" and "muddle through" uncertainty with some problem solving, but if uncertainty has significant ramifications, it can at times lead to irreversible harm, with goals becoming out of reach, investments wasted, and harm being brought unnecessarily to populations and ecosystems. Plans and policies will need to be designed in a manner that they can be robust under multiple future scenarios.

Figure 3: Uncertainty



Contending with Uncertainty

How are planning processes to be proactive in the face of uncertainty? For example, how is an agricultural planning ministry to create long-term plans for crop planting when some models project average surface air temperatures over the continent of Africa to increase by 3-4°C by the end of the century, while others predict up to 7°C or even 9°C over the same time frame (Boko et al. 2007)? This is further complicated by a deficit of sub-continental forecasts.

By 2080, precipitation changes in central and tropical South America could range from -20 to -40% to +5 to +10% (Magrin et al. 2007). How can planners and policymakers make robust decisions that will withstand all possible outcomes?

Should forest managers in the Amazon prepare for a scenario in which portions of the forest are transformed into a savannah-like ecosystem as a result of changes in moisture?

How are water planning ministries across South and Southeast Asia to take into account the extent of populations to experience water stress by the 2020s – projected to be between 120 million to 1.2 billion (Cruz et al. 2007)?

The direction of future precipitation change in small island states is unclear (Mimura et al. 2007). How does one plan for the future under such uncertainty?

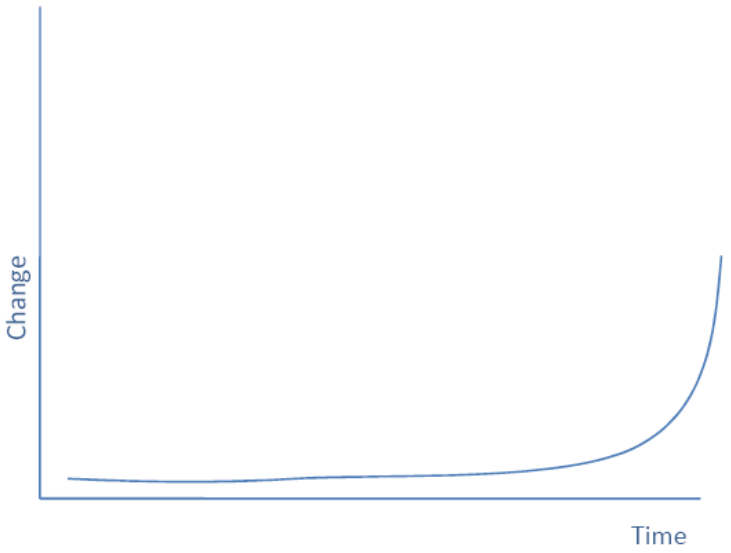
Temporal and Spatial Scales

Even if our global community were to agree to substantial greenhouse gas abatement, the time scale of response can be long after atmospheric concentrations of greenhouse gases are stabilized. The delay in both temperatures and sea level rise will result in compounding impacts to human-built and natural environments. And impacts are cumulative and, thus, present cascading effects (Solomon et al. 2007). Some of the incremental change resulting, if not addressed in the near term, could manifest itself into significant, potentially irreversible, change only decades later (see Figure 4).

Moreover, some of the impacts have the potential for triggering positive and negative feedback loops with change accelerating in later years. For example, positive feedbacks can be kickstarted by changes in the terrestrial sinks of carbon dioxide and methane; the decline in the ocean sink (e.g. as algal growth precludes CO_2 absorption, ions from calcium carbonate-based shells are released and the ocean becomes more saturated with CO_2); and/or changes in surface reflectivity, or albedo (e.g. from loss of snow and ice cover), which results in further solar absorption and warming. Such positive feedbacks can lead to overshooting of thresholds in natural systems, beyond which ecosystems can shift altogether and can be altered dramatically.

In addition to the challenges presented by the temporal scale of climate impacts, decision makers will be faced with hurdles presented by the spatial scale of impacts. Unlike many other environmental problems, climate change risks will be relevant to most sectors and impacts will be borne across the globe, albeit at different magnitudes. While certain actors have contributed to the buildup of greenhouse gases more than others, the risks posed by climate change will display far beyond the source of emissions, unlike more localized pollutants.

Figure 4: Temporal Scale



Contending with Temporal and Spatial Scales of Climate Change

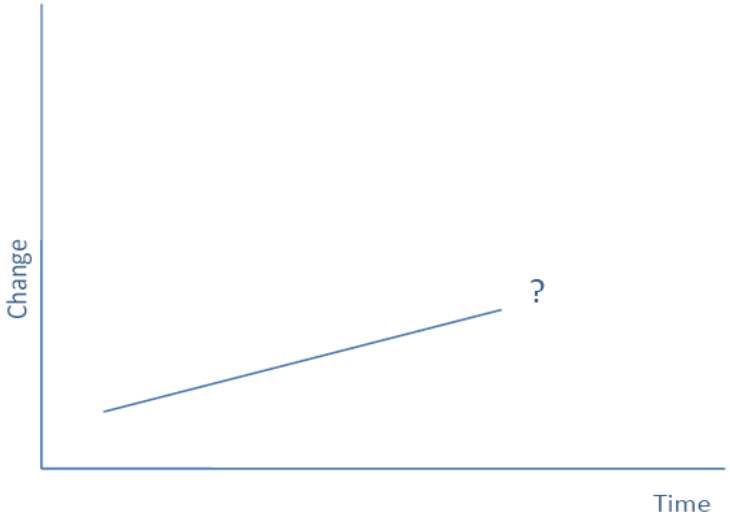
How should decision makers balance the need for responding to immediate concerns while also preparing for long-term impacts that necessitate early action on their part?

For example, three West African coastal megacities are each projected to hold more than 8 million people by 2015. While this growth occurs, sea level rise is projected to result in significant impacts to these megacities (Boko et al. 2007). Even if risks from sea level rise manifest themselves decades later, what actions should decision makers take today to enhance the resilience of and reduce the risks to these coastal inhabitants? How can urban planning be designed to reduce vulnerabilities of concentrated populations to projected storm surges and floods? Can planners prepare for the transition of entire sectors (e.g. certain agricultural practices or tourism activities) that are no longer viable in a changing climate?

Surprises

There are some impacts that decision makers will neither be able to assign probabilities nor anticipate (see Figure 5). Climate change surprises can result from non-linear responses of the climate system, presenting unanticipated outcomes. Scientists have developed the term "large-scale singularities" to describe the potential for abrupt changes in the climate system that result from incremental changes. For example, the build-up of greenhouse gas concentrations could lead to unexpected rates of ice sheet collapse. With all large-scale singularities, scientists suggest that the scale, timing, and occurrence are difficult, if not impossible, to anticipate. If decision making is to be designed for a changing climate, it must deal effectively with the potential for surprises.

Figure 5: Surprises



Contending with Climate Surprises

How does a policymaker in a neighboring country respond to unexpected migration of a non-native pest due to altered temperature regimes that results in novel disease patterns and demands on health resources? How does a natural resources manager respond to an ecosystem rapidly changing to a different, more resilient state, with implications for communities that depend upon services provided by that ecosystem?

What if natural climate variability reacts differently from the way it has in the past – in a manner that is unpredictable – and agricultural plans have to rapidly change to accommodate new patterns?

Towards Decision Making in a Changing Climate: Research Objective

If planners and policymakers are motivated to incorporate climate risks into decisions only when there is a reasonable certainty that risks will be realized, and that they will be realized imminently, action may come too late and opportunities to contend with some impacts may be lost. Decision-making processes must, therefore, be proactive – anticipating climate change's *changes in the mean state of the climate system and its variability* and the *temporal and spatial scales* of climate impacts – if planning and policy objectives are to be met in a changing climate. Additionally, to contend with climate change's s*urprises*, decision making must also be designed to be responsive and flexible to adjust to changes and new information. At the same time, decisions must be robust given the *uncertainty* surrounding climate risks if they are to enable communities and ecosystems to prepare for a variety of possible scenarios of impacts. And, lastly, given the long-lasting nature and magnitude of climate change's impacts, as a result of the *temporal and spatial scales* of climate impacts, decision-making processes must be durable. See Figure 6.

Accordingly, the research objective of *World Resources 2010* is to determine which options are available to decision makers that enable the advancement of policies and plans that prepare for and respond to a changing climate. The Report will identify ingredients (conditions, capacities, and other factors) for – as well as hurdles to – decision making that:

(1) is able to respond to change quickly to contend with unanticipated surprises;

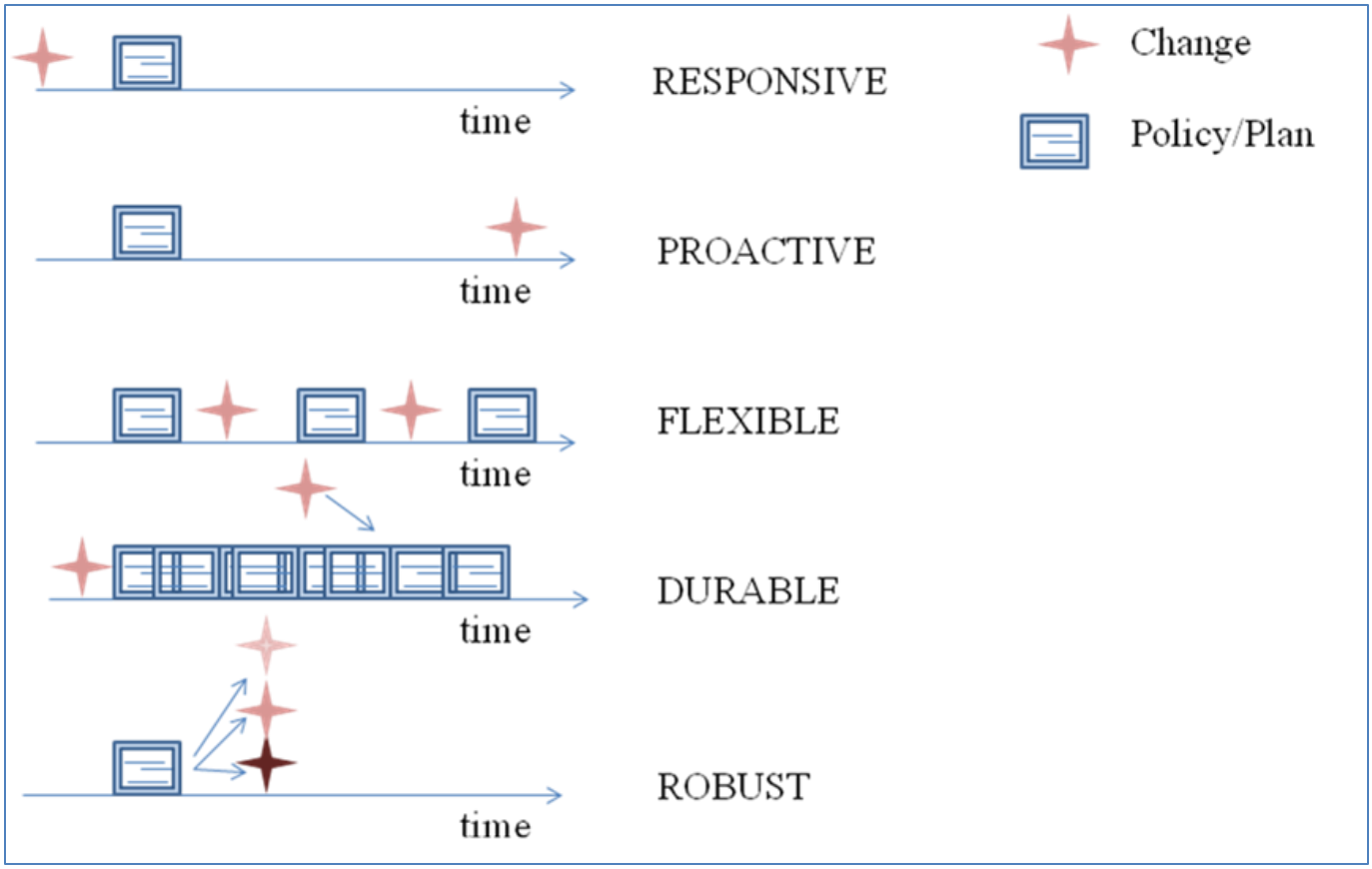
(2) deals proactively with future climate change risk, advancing interventions in light of impacts that may only manifest themselves far into the future but which are of necessity demand early intervention;

(3) is flexible and can adapt to new information and conditions;

(4) is durable, responding to the long-term nature of climate change; and

(5) is robust, withstanding uncertainty and serving multiple climate scenarios.

Figure 6: Attributes of Decision Making in a Changing Climate



Building on Existing Research as a Foundation for *WRR 2010*

World Resources 2010 will build upon existing research and assess its applicability to adaptation and to interventions in the developing world. The literature has delineated attributes of decision-making processes that could lead to more responsive, proactive, flexible, durable and robust decision making, therefore holding important lessons for *World Resources 2010.*

For example, one relevant body of literature focuses on "adaptive decision making," which refers to the ability not only to adjust and react to new change but also to anticipate change.[1,2] Literature on adaptive decision making suggests that the most

[1] Insofar as adaptive constitutes "the capacity for adaptation," this is in line with the IPCC's definition of adaptation: an "adjustment in natural or human systems in response to actual and *expected* [emphasis added] stimuli or their effects..."

[2] Scholarship on adaptive decision making was developed from that of adaptive management. Adaptive management was coined in the late 1970s to contend with the weaknesses of conventional management tools and was first defined as "flexible, diverse and redundant regulation, monitoring that leads to corrective action and experimental problem of the

critical function of adaptive governance is its capacity to "learn" (Kemp and Weehuizen 2005). Learning can be facilitated through continuous monitoring and performance review (Breit et al. 2003), which can lead to corrective action. Policies can include amendment procedures to retain flexibility (Hurrell and Kingsbury 1992). The ability to learn from mistakes will be a critical element of adaptive decision making (Ingraham 1994). An important characteristic of a learning structure is an institutional culture that encourages experimentation and does not severely penalize failure (Ingraham 1994).

The scholarly literature also suggests that adaptive governance requires novel means for coordination (Irwin and Ranganathan, 2007 and Breit et al. 2003) due to the complex nature of the problems that need to be governed adaptively. Coordination must be carried out horizontally, across levels of problem management, as well as vertically, across the decision-making process (Prestre 2002). For example, decision making in a changing climate will bring to the fore the need to adopt and implement more integrated approaches to tackling climate and non-climate drivers of ecosystem degradation, as well as implications for development, together.

In addition to learning and coordination, the development of capacities for the generation and dissemination of information that serves the needs of decision makers will also be critical. Also, the literature suggests that additional financial resources will be required for future demands and to enhance emergency preparedness (Ingraham 1994).

The World Bank's *Global Report of the Economics of Adaptation to Climate Change* underscores the notion that adaptation costs will be significant and that decision makers will be increasingly faced with competing priorities.

Environment and development research institutions have recently begun to translate lessons from the academic literature for practitioners. The US National Research Council's reports on climate change (2010a, 2010b) discuss the need for policy mechanisms that are both durable and adaptable. A multi-year study performed by IISD and TERI synthesized much of the literature on adaptive governance and tested its findings in case studies within India and Canada. Based on their empirical findings, IISD and TERI call for the adoption of seven tools for adaptive decision making: integrated and forward-looking analysis; multi-stakeholder deliberation; automatic policy adjustment; self-organization and social networking; decentralization of decision making; promotion of variation; and formal policy review and continuous learning (Swanson and Bhadwal 2009). While the IISD/TERI research was focused on decision making more broadly, the Tyndall Centre, University of East Anglia, and Utrecht University recently performed a scoping exercise on the ways in which various adaptation decision-making frameworks can contend with uncertainty and surprises related to climate change (Dessai and van der Sluijs 2007).

Significant attention has also been devoted to identifying which national-level functions will need to be performed for effective adaptation decision making. The UN Development Programme has developed adaptation policy frameworks to guide formulation and implementation of adaptation policies, measures and strategies (Lim and Spanger-Siegfried 2004). In addition, UNDP's 2007/2008

continually changing reality of the external world" (Holling 1995 and Oglethorpe 2002). Adaptive management overcomes major hurdles of traditional management, as it increases adaptive capacity and incorporates uncertainty and surprises more readily.

Human Development Report draws lessons from adaptation planning and policymaking in both developed and developing countries (Watkins 2007). The World Resources Institute, in consultation with adaptation experts and others, has developed the National Adaptive Capacity (NAC) Framework and Adaptation Rapid Institutional Analysis (ARIA) which identify the following necessary functions for incorporating climate risk into decision making: assessment, prioritization, information management, coordination, and risk reduction (WRI 2009b). Other research efforts have identified principles – such as effectiveness, efficiency, equity, and legitimacy (Adger et al. 2005) – that should be embraced by adaptation decision makers. Many features of effective adaptation decision making overlap with features of good governance more broadly.

Also, several important lessons can be found in previous *World Resources Reports*, which have addressed the important linkages between development, the environment and governance. For example, *World Resources 2008* argues that properly designed nature-based enterprises can create economic, social, and environmental resilience that cushions the impacts of climate change. In addition, the World Bank's *World Development Report 2010: Development and Climate Change* holds important lessons with regard to how our society must act differently in a changing climate, such as overcoming institutional inertia and fostering policy change.

World Resources 2010 will build on the existing literature and unravel determinants of effective decision making. The Report will make the academic and other literature on the topic more accessible and concrete to decision makers, working to uncover detailed examples of how the abovementioned ingredients for more responsive, proactive, flexible, durable, and robust decision making can be realized in practice on the ground.

Research Approach

World Resources 2010 is embracing a new model that engages audiences from its inception, throughout research activities, and in the eventual development of the Report's guidance. This is a key break from past practice. Earlier *World Resources Reports* were prepared internally, with appropriate external consultation, over a period of 18-24 months, before a final Report was made public. This new approach involves a shorter time frame and a far more open, interactive, and visible process for the Report's research activities and eventual development of guidance for decision making and implications for development assistance.

Central to the *World Resources 2010* is an interactive website (www.worldresourcesreport.org). Possible elements include an adaptation news section, calendar of events, and novel maps, data, and charts. It will also host the Report's content as it is developed through various research activities, including commissioned papers and commentaries, case study research and supplemental research, and in-person convenings, as discussed below. Research activities will focus on identifying the conditions and capacities for, and hurdles to, decision making in a changing climate. The research findings will then be translated into practical guidance for decision makers. The following section describes the Report's research approach in greater detail.

Case Studies

World Resources 2010 will be reviewing the literature and approaching experts and practitioners

for examples of national-level decision making processes, especially in developing countries, that have succeeded in, or confronted challenges in, integrating short-term and long-term risks. For example, we would look to highlight a case study in which integrated water resource planning succeeded in folding climate risks into long-term management, and the factors why the process succeeded in doing so. We are seeking to identify case studies within the following sectors:

- coastal zone management
- water
- forest management
- agriculture
- electricity production
- transportation planning

We have chosen to proceed on a sectoral basis because many policies and plans are carried out in this manner. However, we recognize that there could be unforeseen consequences of a sectoral approach. For example, a water ministry may develop a novel system for storing water but without collaborating with the health ministry, it may not plan for increased malaria risks borne to the region. The national-level focus may also create maladaptations across the borders, since ecosystems do not lie in sovereign nation state boundaries. We will therefore complement the sectoral case study research with cross-sectoral and regional cases as relevant. While any set of sectors will inevitably be arbitrary, we have chosen 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 expertise. Depending upon case study availability, we may choose to amend this list of sectors.

While some developing countries have now drafted strategic plans for climate adaptation, far fewer have moved beyond the planning phase and have begun to incorporate climate risks into specific policies and programs. We are seeking to identify case studies that have moved beyond the planning stage and have implemented decisions. We hope to identify case studies that have unfolded in the past so that we will be able to analyze outcomes and distill lessons. We will co-author the case studies with practitioners who have been involved in the decision-making process at hand in an effort to ensure accuracy and relevance.

Given that many national-level decision-making processes that incorporate climate risks are in their infancy, however, we are also looking to identify decision-making processes that have succeeded in responding to or anticipating other types of change. Therefore, we will include, as necessary, case studies that demonstrate a decision-making process' ability to contend with change that is driven by non-climate perturbations.

Within each sector, we will examine two to three examples of national-level decision making processes that have been able to (1) deal proactively with uncertainties and plan for changes in the mean state and variability of the climate, as well as the lag of climate impacts; (2) respond to change quickly to contend with surprises; (3) are flexible, adapting to new information and change; (4) are robust under uncertainty; and/or (5) are durable to contend with the temporal and spatial scales of climate impacts. *World Resources 2010* will examine case studies that have both succeeded and failed to advance such decision making. We do so not only to identify the resources, capacities and conditions critical to decision making in a changing climate but also in an effort to identify related hurdles.

(1) *Proactive decision making:* With regard to anticipating risks and uncertainty, we differentiate between short-term impacts (seasonal to decadal, e.g. altered precipitation levels, changes in the seasonality and volume of glacial meltwater flow, pest outbreaks, etc.) and long-term impacts (multi-decadal, e.g. disappearance of various services provided by ecosystems, loss of freshwater sources, eventual threats of sea level rise, etc.). Conditions and capacities that allow for short-term anticipatory decision making will likely differ from those that allow for long-term planning. Case study research will examine hurdles to and conditions/capacities (institutional, financial, biological resources, and other) that enable decision making to embrace both short- and long-term risks.

(2) *Responsive decision making:* With regard to decision making that can cope with surprises and be responsive, case study research will examine both hurdles to and conditions/capacities (institutional, financial, biological resources, and other) that enable rapid response capabilities. We will also examine case studies that demonstrate examples in which once rare disturbances have become persistent (e.g. the catastrophic hurricane that once came every half century but has arrived every decade now; month-long – or longer – dry episodes that occur more often than historically) and have catalyzed proactive decision making (e.g. the creation of early warning systems and movement of vulnerable communities away from high risk locations; changing integrated water resource plans to prepare for such dry episodes). In other words, we will seek to examine the conditions/capacities that facilitate the transformation of responsive decision making to proactive decision making.

(3) *Flexible decision making:* Similar to the notion of responsive decision making, flexible decision making will enable continuous updating to policies and plans in light of new information and change. Case study research will seek to identify those attributes of a decision-making process that foster flexibility, as well as institutional and other bottlenecks that inhibit flexibility. Building upon the literature on adaptive decision making, the research will provide additional detail on determinants of and hurdles to flexible decision making at the national level.

(4) *Robust decision making:* Case study research will identify those features of a decision-making process that enable or hinder the ability to prepare for and withstand multiple futures.

(5) *Durable decision making:* Case study research will seek to identify ways in which policy and planning responses can become durable and long-lasting. Particular attention will be devoted to exploring whether those determinants of durable decision making preclude flexible decision making.

Our research will draw on experiences in both developed and developing countries. However, because those that will be most severely impacted are developing countries, with few to no resources available to dedicate towards adaptation, we will place particular emphasis on lessons that could be applicable to them. While our focus is on national-level decision making, the Report will seek to identify the national- and sub-national-level enabling environments that would result in interventions targeted at the most vulnerable populations and ecosystems.

Commissioned Papers and Commentary

One key set of activities that *World Resources 2010* is undertaking is a series of commissioned papers from prominent thought leaders and practitioners in response to relevant policy questions. For each question in the series, we will be asking roughly five experts to prepare a paper that addresses the question at hand. The WRR team will provide a short overview of the question in an effort to guide authors in their response. Subsequently, up to five commentators will review these commissioned papers and provide a short response. We hope that the exchange, which will be highlighted on the WRR website, will provide a wide range of input on important issues related to the topic of the 2010 Report. We will also provide a space on our website for general comments on the dialogue, likely through password protected participation to ensure credible exchange.

The questions asked will not be easily resolved. As a result, we are asking for lessons learned and opinions gathered from experiences in research and decision making. Commissioned authors will be asked questions such as those listed below. While the first series' question focuses more on discourse, the questions following are more concrete and were chosen in an effort to build on lessons from relevant academic and gray literature, further identifying tools and prescriptions for decision making in a changing climate.

Commissioned Paper Series #1: The first paper series will examine the following question: is the way we currently plan for the future and react to unexpected change sufficient to accommodate the uncertainty, scale, long lead time, and complexity associated with climate impacts? A number of other challenges, such as the persistence of toxics and ecosystem degradation, also have long-term consequences that are difficult to predict fully. In addition, development and environmental decision making has changed significantly over the past few decades (e.g. after the Brundtland Commission). Other perturbations, such as those posed by natural disasters, present significant uncertainty and require upfront costs, and decision making processes have been established to contend with such risks. The paper series will ask

experts whether current decision-making paradigms are able to incorporate the long-term nature, surprises, heightened change and variability, and uncertainty of a changing climate, or whether such climate change requires entirely new planning and policymaking processes. If so, what needs to change? If not, how should current processes be harnessed to plan for and react to climate risks today and in the future?

Commissioned Paper Series #2: This series will examine how decision makers can choose among competing near- and long-term priorities. How can both current and future climate change risks best be taken into account in prioritization processes? What challenges must be addressed in order to enable the prioritization of near-term actions that may not demonstrate a benefit for quite a long while? How can the decision maker faced with long-term risks reconcile the need for early action to mitigate future impacts with the need to engage a citizenry whose focus may be more near-term oriented? And what economic and other incentives can be created for decision makers to prioritize risks that will manifest themselves long after their term in office is completed, especially if resources are limited?

Commissioned Paper Series #3: The third commissioned paper series will explore how development agencies can assist national-level planning and policy-making processes to integrate climate risks. Leading thinkers from aid agencies and recipients of funding will be asked what role development agencies can play in supporting the integration of climate risks into national-level planning and policymaking.

Commissioned Paper Series #4: The fourth commissioned paper series will delve into one of the determinants of effective integration of climate risks into planning and policymaking: information. The series will ask authors what types of information about a given impact are needed before a decision maker can act to integrate such risk into plans and policies. Also, authors will be asked, given climate change's uncertainty and surprises, what types of information are needed for policy adjustment if decisions need to be changed to contend with novel circumstances. Another set of questions will focus on how information can be most effectively collected and disseminated.

Commissioned Paper Series #5: The fifth commissioned paper series will build upon previous World Resources Reports and assess whether we need to adopt a fundamentally different approach to conserving ecosystems and their services in a changing climate. This question seeks to address whether we should continue with

existing practices for incorporating ecosystems into decision-making processes and overcome related barriers with more urgency, or whether we need radically different approaches in the way we contend with the additional stress of climate change on ecosystems.

Commissioned Paper Series #6: The last commissioned paper series will examine the roles of both the private sector and civil society in national-level integration of climate risks into planning and policymaking. Authors from civil society organizations and the private sector will be asked to contribute.

The questions will be further refined during the course of research.

Scenario Exercises

Throughout the course of 2010, the *World Resources Report* team will convene two in-person meetings to conduct scenario exercises. Hypothetical scenarios of climate change impacts that demand incorporation of both short- and long-term climate risks into planning processes will be presented. The purpose of the convenings will be to explore how participants would plan for such situations. This exercise will seek to unravel critical hurdles to, as well as necessary conditions and capacities for, contending with the climate change risks presented.

For the development and facilitation of the exercises, we will partner with the Consensus Building Institute, a non-profit organization that uses tested techniques and principles for improved group decision-making for complex issues. Strategies embraced during scenario exercises have been developed through programs on negotiation and public dispute programs at the Massachusetts Institute of Technology (MIT) and Harvard Law School. The Institute has used scenario exercises to help plan for land use conflicts, facility siting controversies, public policy disagreements, and confrontations over water, and has increasingly been designing meetings around responding to and planning for climate risks.

Currently, we envision that the exercises would take one to two days. The first part would be a role-playing exercise planning for a future climate scenario in an effort to tease out the challenges and opportunities of addressing current and future climate risks. The second part of the exercise would consist of a debriefing and discussion around the capacities and conditions required for, and hurdles to, integration of climate risks into planning. Participants would include national-level decision makers, development agencies, academia and civil society organizations. We plan to work with the following scenarios, which would be hosted in the associated countries:

Electricity – Ghana: Climate projections suggest that Ghana will face lower precipitation, more frequent droughts, and enhanced evaporation, altering reservoirs, such as that of the Akosombo dam, which currently provides 70% of the country's electricity supply. During periods of low water levels, the dam's capacity is cut by two thirds. Participants will include energy sector planners.

Agriculture – Vietnam: As a result of sea level rise, the Mekong River Delta, known as the "rice granary" of the country as it produces more than half of the country's rice supply and 90% of its rice exports, could witness significant amounts of land area submerged, with detrimental effects to the crops and the nation's economy. For example, with sea level rise of one meter, 15,000 to 20,000 km^2 of the Mekong River delta are projected to be flooded (Cruz et al. 2007).

Additional In-Person Roundtables

In addition to scenario exercises, the *World Resources Report* team will organize two roundtables to explore the issues of governmental coordination and the role of information in incorporating climate change risks into decision making processes. The first roundtable will also identify information needs and models for information collection and dissemination. The second discussion will assess emerging models for coordination (horizontal across ministries and vertically from local to national levels) and pitfalls encountered in coordination. Members of the roundtables, which will take place both virtually online as well as in person would include decision makers from developing countries as well as experts in coordination and information.

Synthesis Report: Guidance on Decision Making

The empirical findings from the case studies and the lessons learned through commissioned papers, scenario exercises, and in-person and online roundtables will pave the way for a synthesis report, which will present policy guidance for integrating climate risks into national-level planning and policymaking and the implications for development assistance.

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DEFINITIONS

Adapted from the Intergovernmental Panel on Climate Change's Fourth Assessment Report's Glossary of Terms (2007)

Adaptation
Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. Various types of adaptation can be distinguished, including anticipatory, autonomous and planned adaptation.

Anthropogenic
Resulting from or produced by human beings.

Climate
Average weather in a narrow sense, 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 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.

Climate change
A change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcings, or to persistent anthropogenic changes in the composition of the atmosphere or in land use. Note that Article 1 of the Framework Convention on Climate Change (UNFCCC) defines climate change as "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods." The UNFCCC thus makes a distinction between climate change attributable to human activities altering the atmospheric composition and climate variability attributable to natural causes.

Climate variability
Variations in the mean state and other statistics (such as standard deviations, the occurrence of extremes, etc.) of the climate on all spatial and temporal 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).

Climate scenario
A plausible and often simplified representation of the future climate, based on an internally consistent set of climatological relationships that has been constructed for explicit use in investigating the potential consequences of anthropogenic climate change, often serving as input to impact models. Climate projections

often serve as the raw material for constructing climate scenarios, but climate scenarios usually require additional information such as about the observed current climate.

Ecosystem approach

A strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way. An ecosystem approach is based on the application of appropriate scientific methodologies focused on levels of biological organization, which encompass the essential structure, processes, functions and interactions among organisms and their environment. It recognizes that humans, with their cultural diversity, are an integral component of many ecosystems. The ecosystem approach requires adaptive management to deal with the complex and dynamic nature of ecosystems and the absence of complete knowledge or understanding of their functioning. Priority targets are conservation of biodiversity and of the ecosystem structure and functioning in order to maintain ecosystem services.

Ecosystem services

Ecological processes or functions having monetary or non-monetary value to individuals or society at large. These include (i) supporting services such as productivity or biodiversity maintenance, (ii) provisioning services such as food, fibre, or fish, (iii) regulating services such as climate regulation or carbon sequestration, and (iv) cultural services such as tourism or spiritual and aesthetic appreciation.

Extreme weather event

A weather event is an event that is rare at a particular place and time of year. Definitions of rare vary, but an extreme weather event would normally be as rare as or rarer than the 10th or 90th percentile of the observed probability density function. By definition, the characteristics of what is called extreme weather may vary from place to place in an absolute sense.

Greenhouse gas (GHG)

Those gaseous constituents of the atmosphere, both natural and anthropogenic, that absorb and emit radiation at specific wavelengths within the spectrum of thermal infrared radiation emitted by the Earth's surface, the atmosphere itself, and by clouds. This property causes the greenhouse effect. Water vapor (H2O), carbon dioxide (CO2), nitrous oxide (N2O), methane (CH4) and ozone (O3) are the primary greenhouse gases in the Earth's atmosphere. Moreover, there are a number of entirely human-made greenhouse gases in the atmosphere, such as the halocarbons and other chlorine- and bromine-containing substances, dealt with under the Montreal Protocol.

Impacts of (climate change)

The effects of climate change on natural and human systems. Depending on the consideration of adaptation, one can distinguish between potential impacts and residual impacts.

Large-scale singularities

Abrupt and dramatic changes in the state of a system in response to gradual changes in driving forces. For example, a gradual increase in atmospheric greenhouse gas concentrations may lead to such large-scale

singularities as slowdown or collapse of the thermohaline circulation or collapse of the West Antarctic ice sheet. The occurrence, magnitude, and timing of large-scale singularities are difficult to predict.

Mean state of the climate system

Long-term average state of annual and seasonal values of climatic components of the climate system including the atmosphere, oceans, cryosphere (ice sheets), biosphere (living organisms), and geopshere (rocks, soils, and sediments).

Non-linearity

A state in which there is no simple proportional relation between cause and effect.

Resilience

The ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity for self-organization, and the capacity to adapt to stress and change.

Uncertainty

An expression of the degree to which a value (e.g., the future state of the climate system) is unknown. Uncertainty can result from lack of information or from disagreement about what is known or even knowable. It may have many types of sources, ranging from quantifiable errors in the data to ambiguously defined concepts or terminology to uncertain projections of human behavior. Uncertainty can therefore be represented by quantitative measures, for example, a range of values calculated by various models, or by qualitative statements, for example, reflecting the judgment of a team of experts (see Moss and Schneider, 2000 and Manning et al., 2004).

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.

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