World Development Report 2010

Development in a Changing Climate

Concept note

LIKELY KEY MESSAGES OF THE REPORT

Climate change is only one of many challenges facing developing countries—but, mismanaged, it will reverse development progress. Developing countries are faced with immediate needs and limited resources, continued poverty, and social and environmental challenges. In many of them, human and institutional resources are scarce and overstretched. And development assistance is less than half the amount committed by industrialized countries at the 2002 Monterrey Conference. In this context, the temptation is strong to focus on immediate needs and ignore climate change as the problem rich countries can afford to worry about. Unfortunately, the damaging consequences of unchecked climate change will fall disproportionately on developing countries, particularly on their poorest citizens who are least able to cope.

The magnitude and certainty of the risks associated with climate change justify a strongly precautionary approach. This is not only due to ethical concerns about saddling future generations with a potentially catastrophic and irreversible situation: the very pace of climate change is already stretching the ability of human and natural systems to adapt. And while it is tempting to say that good development will take care of most adaptation needs, there are limits to what physical, ecological, and human systems can adapt to. Losses mount and adaptation options narrow at about 2ºC above pre-industrial levels, justifying the need to stay below that level of warming.

Tackling climate change requires pricing carbon, but also addressing other critical market failures. Carbon must be priced since it is the only way for the costs of carbon emissions to be reflected in investment and consumption decisions. However, a host of other market failures linked to information, risks, liquidity constraints, externalities, and transaction costs also stand in the way of effective climate action and will require policy responses. These failures must be addressed if the private sector is to respond effectively to the changing climate.

Developed countries must take the lead on mitigation, but all countries have a stake in solving the problems of climate change. Developing countries are the most vulnerable to severe climate impacts. Industrialized countries are already obligated to provide financial and technical support to less developed countries. Analyses of mitigation paths show that it is also in the economic interest of industrialized countries to assist developing countries in accelerating their abatement efforts.

"Climate-wise" development policies are needed to manage the conflicting demands that adaptation and mitigation place upon limited or costly resources such as land, water, and energy. Policy actions are also needed to protect people from shocks or help them adjust to changing circumstances. But even as climate change makes development more complex, it also creates a much needed momentum for reforms to achieve long-pursued, critical policy goals such as sustainable land and water resource management and strategic approaches to long-term health and environmental threats.

The Bali Action Plan on adaptation and mitigation needs to trigger transformative changes equivalent to a global green industrial revolution. Only strong political will and leadership can initiate the urgent and dramatic actions that are needed for the emergence of a fair, yet efficient, solution to the climate challenge.

Objectives

1. We are at a critical juncture. The Kyoto Protocol was agreed to over a decade ago and we are now in the first period of rigorous accounting of emissions by developed countries. However, greenhouse gases in the atmosphere are still increasing, possibly at an accelerating rate (Raupach et al 2007). There are real and immediate concerns that global warming associated with such trends could reverse the development gains of recent years. There are equal concerns that some of the policy responses triggered by these trends could also be harmful to growth and poverty alleviation objectives.

2. The "Bali Road Map", which was adopted at the 13th Session of the Parties to the United Nations Framework Convention on Climate Change (UNFCCC) in Bali in December 2007, explicitly acknowledges development concerns. Formal negotiations are set to conclude at the Climate Change Conference in Copenhagen in December 2009.[1] Reaching a deal that is adequate, achievable, and acceptable to all has become urgent. Without it, the scramble to address the energy challenges of today (including fears about the cost and reliability of hydrocarbon supply) risks locking the world into unsustainable technologies and emission trajectories that would make it very difficult to avoid unmanageable impacts or runaway global warming. Finally, without a global climate deal that tackles the need for adequate resources for adaptation, it is unlikely that an adequate mitigation agreement would be reached.

3. In this context, this World Development Report has three objectives: First, to help convince the development community that climate change really does represent a changing climate for development, and that development, "the way we've always done it", is not a good way forward. Second, the Report aims to join its voice to a growing chorus that argues that unless development realities are fully integrated into climate change agreements, such agreements will fail to deliver significant mitigation and/or will simply not be accepted by developing countries. A particular concern is to ensure that the voices and interests of the poorer and smaller countries are also taken into account.

4. A third objective of this Report is to contribute to the small but growing body of knowledge on how development policy should be designed in a greenhouse world. Climate change is one of many challenges facing developing countries. Some things, but not everything, need to change; in some cases "climate-wise" policy will simply require doing more or better rather than doing different; in others, difficult trade-offs will arise, or will be accentuated, between immediate needs and longer-term climate related concerns. For some countries, climate change could open up new opportunities as it changes the competitive landscape. Nonetheless, it is clear that traditional patterns of managing infrastructure and ecosystems will need to change—in both developed and developing countries.

[1] The ongoing Climate Change Talks are to take forward work on a strengthened and effective international climate change deal under the UN Framework Convention on Climate Change (UNFCCC), as well as work on emission reduction rules and tools under the Kyoto Protocol (http://unfccc.int).

Value added

5. Many excellent reports have recently been published on climate change, and a number of others are under preparation both within and outside the World Bank (Annex I). This will be very helpful as the team can benefit from a body of existing knowledge and the emerging scientific consensus. However, it does raise the question of what the value added of the Report will be.

6. First, the WDR will focus on what climate change means for development and what development implies for climate change—something few other reports have done with the notable exception of the Human Development Report (UNDP 2007).[2] It will seek to identify the policy implications of climate change for particular aspects of development policy, but also to address what the challenges faced by developing countries—limited resources, overstretched and often weak institutions, rapid urbanization, demographic change, poverty—mean for adaptation and mitigation. And while it will discuss the dire need for new and better technical solutions, the Report will emphasize political economy considerations and the role of institutions and governance since these issues are more often than not the binding constraints to progress. It will not attempt to present an exhaustive discussion of global climate change, something already impeccably done in the reports of the Intergovernmental Panel on Climate Change (IPCC).

7. Second, the WDR will take an integrated look at adaptation and mitigation, whereas most reports look at these issues separately. Economic analysis suggests that adaptation and mitigation are usually substitutes, and joint decisions ("optimization") tend to yield better outcomes than sequential ones. More generally, an integrated analysis helps highlight trade-offs and the competition for resources between development, adaptation and mitigation goals but also the potential actions with co-benefits.

8. Third, rather than discussing adaptation and mitigation through a series of sectoral chapters, the Report will focus on water, land, and energy as the key resources whose supply and demand is changing because of climate change and climate change policies. Sectoral policies (agricultural, urban, environmental, transport, etc.) will be subsumed in the discussion of how to manage basic resources and optimize developmental outcomes. The Report will emphasize resilience and adaptation—including changes in behavior, planning, management, technologies, and institutions—since these issues are the most relevant to poor countries and are also typically less studied.

9. Fourth, the Report will present evidence suggesting that high income countries with emission reduction commitments have a huge financial stake in facilitating early action to limit greenhouse gas emissions in all countries. The combination of living within a carbon budget and delaying incentives for middle-and low- income economies to take up low carbon options could entail enormous excess costs—deadweight losses—for taxpayers in countries with carbon constraints. This research suggests that providing

[2] The IPCC reports on adaptation (IPCC 2007b) and mitigation (IPCC 2007c) each contain a chapter discussing implications for development.

adequate financial incentives for developing countries to participate in global climate action is not a zero-sum game: major welfare gains are possible for all.

10. Fifth, a central thesis of the Report is that global warming and policies to control it affect the competitive landscape. Climate change will alter the flows of goods and materials worldwide by shifting the most productive agricultural regions and changing water supply and quality. This is likely to affect settlement patterns and migration flows. It will imply new challenges for developing countries, but also possibly a new competitive advantage in clean energy, or in the production of green goods. The Report will highlight these new opportunities and the steps needed to take advantage of them, with an explicit focus on the near term (box 1).

Box 1 Time horizon of the WDR

The WDR is expected to inform policy in the *near-term* future, i.e. the decades leading up to 2030. While the focus is on the transformations that have to take place during this period, it is important to note that immediate action is required to achieve a global deal on climate change and establish a framework that will make these transformations possible. At the same time, the near-term actions are informed by *medium-term* targets for emissions by the middle of the century (2050). The Report refers to the *long-term* (2100) in the context of the long-term stabilization of greenhouse gases in the atmosphere.

11. This Report will be published in September 2009, three months before the Copenhagen summit, in a politically charged atmosphere. This has important implications for what the Report should or should not attempt to do. As a major publication of a development institution, the WDR must argue for development concerns to be central to the negotiation process. It must also help voice the concerns of poor people and poor countries. But while the Report will discuss particular concerns and options, it will refrain from taking positions on issues under negotiation. Initial findings from the Report could be released early, for example, in the context of the World Environment Day in June 2009, in order to be available to the UNFCCC process.

Background

12. The climate is changing. There is now scientific consensus that the world is becoming a warmer place. In the words of the IPCC's (2007d) Fourth Assessment Report: "Warming of the climate system is unequivocal." This is visible in the increasing average air and ocean temperatures, the widespread melting of snow and ice, and rising sea levels. Cold days, cold nights, and frost have become less frequent while heat waves have increased. Globally, precipitation has increased even while regions such as the Sahel and Mediterranean have seen more frequent and intense droughts. Heavy rainfall and floods have become more common, and there is some evidence that the intensity of storms and tropical cyclones has increased.

Development gains are vulnerable to climate change

13. The last two decades have seen the largest decrease in absolute poverty in history. The first Millennium Development Goal target—halving the proportion of people living in extreme poverty—will be met well ahead of the proposed 2015 deadline if the observed trend continues: the proportion of people living on less than 1.25 dollars a day fell to 26 percent in 2005 (Chen and Ravallion 2008). This implies some 400 million people are not in extreme poverty anymore. Over the same period, global child mortality rates have dropped from 106 to 83 deaths per thousand live births and life expectancy has increased by three years (UNDP 2007). Economic growth around the world has accelerated, mainly driven by fast growing large economies like China and India but also by a recent improvement in economic performance in Sub-Saharan Africa.

14. Despite these advances, large development challenges remain. Close to half the world's population (48 percent) is still in poverty, living on less than 2 dollars a day. Nearly a quarter of the world's people—1.6 billion—does not have access to electricity (IEA 2007), and one in six people don't have access to clean water (UN 2008). Life expectancy in Sub-Saharan Africa in 2005 was lower than 15 years earlier and well below the world's average (UN 2006). Around 10 million children under five still die each year from preventable diseases such as respiratory infections, measles, and diarrhea (UN 2008). Large inequalities remain within countries: in developing countries, child mortality rates in the bottom quintile are typically twice as high as in the top quintile (Gwatkin et al. 2007).

15. Climate change will add to the many stresses faced by developing nations, as well as poor people in rich countries, and could reverse recent progress. Studies point to projected decreases in agricultural productivity in the poorest regions in the world, compounding inequalities between poor and rich countries (Cline 2007, Dinar et al. 2008). Resulting food insecurity, combined with increased food, energy, and transport prices, has already and will continue to undermine social stability in some regions. Malnutrition rates are likely to increase. Other health outcomes are also likely to worsen. The total number of people exposed to malaria, dengue, and unsafe food and water will increase as temperatures rise. The World Health Organization (WHO) estimates that 150,000 deaths can already be attributed to climate change annually (WHO 2006).

16. Floods and droughts will be more severe with climate change. Droughts have immediate harmful impacts on poverty rates and economic growth, but also long-lasting effects on lifetime earnings and health (Dercon and Hoddinott 2004). Other extreme events, such as cyclones, are likely to increase in intensity and severity. Nordhaus (2006) estimates that warming-related increases in hurricane wind speed will result in additional damages of 8 billion dollars per year in the U.S. alone.

17. The increased variability in weather patterns will create an extra burden for people without access to insurance, credit markets or social protection. Some of the actions taken by households to minimize the short-term impacts of climate change can have long-term consequences: for example, if people sell their assets in the face of repeated droughts, they compromise the generation of future income. Similarly, if

children are taken out of school in order to work, their future social and productive potential is diminished.

18. Climate change also threatens sustainability of the development process. The disappearance of ecosystems will imply the loss of the services they provide. For example, coral reef systems might suffer substantive bleaching, as increases in temperature accelerate the rate of species extinction. Further, it is likely that ocean acidification will negatively affect already strained fish stocks and significantly disrupt marine ecosystems.

19. The development process can also be affected by policy responses to climate change, particularly if poorly designed. A case in point is biofuels policies in the United States and Europe: increased biofuels production in these countries was a significant factor in the recent rise in food prices (World Bank 2008a). The overall impact on poverty depends on the structure of the economy—since net producers will benefit from higher prices and net buyers will be worse off—but higher food prices are usually associated with an increase in poverty rates (Ivanic and Martin 2008). Many governments in net surplus countries have responded with export bans and other protectionist measures, limiting the scope for future market solutions to similar problems.

20. The direct and indirect effects of climate change could wipe out much of the progress seen in recent years. Global estimates of poverty that take into account the increase in food prices might show a reversal of the steady decline in poverty rates of the previous few years. Moreover, since some of the effects of climate change on development will unfold over the next decades, we may prematurely declare victory with respect to the Millennium Development Goals in 2015, with major setbacks caused by climate change only appearing afterwards. Even if, being optimistic, we celebrate in 2015 our success in fostering development, unmitigated climate change, and badly designed policies will obscure the celebration shortly thereafter.

Human activity is causing global warming

21. Greenhouse gas (GHG) emissions due to human activities are the source of most global warming (box 2). GHGs have increased dramatically since the beginning of the industrial revolution, and most rapidly in the last 50 years. Global atmospheric concentrations of carbon dioxide, the most important greenhouse gas, had ranged between 200 and 300 parts per million (ppm) for the last 750,000 years. Over the last century, concentrations have increased from 280 ppm to about 380 ppm (or by more than a third), mainly because of the burning of fossil fuels and, to a lesser extent, land use change. Other heat-trapping gases such as methane and nitrous oxides have also increased dramatically as a result of fossil fuel combustion, farming activities, and land use change. To date, the Earth's temperature has increased by almost one degree Celsius.

Box 2 The increasing consensus around the fact that climate change is caused by human activities

The Intergovernmental Panel on Climate Change (IPCC) is a scientific intergovernmental body set up by the World Meteorological Organization (WMO) and by the United Nations Environment Program (UNEP) in 1988 in order to provide policymakers with an objective assessment of the causes of climate change, its potential environmental and socioeconomic consequences and the adaptation and mitigation options to respond to it. All IPCC reports go through a rigorous review process and an adoption and approval process that is open to all member governments. IPCC conclusions are generally considered to represent the consensus view of the scientific community.

INCREASING SCIENTIFIC CERTAINTY: THE CONCLUSIONS OF THE FOUR IPCC ASSESSMENTS

1990 …the observed increased [in temperatures] could be largely due to…natural variability; alternatively….other man-made factors could have offset a still larger man-made greenhouse warming.

1995 …The balance of evidence suggests a discernible human influence on global climate.

2001 …most of the observed warming over the last 50 years is likely […] due to the increase in greenhouse gas concentrations.

2007 Most of the observed increase in globally averaged temperatures since the mid-20th century is very likely due to the observed increase in anthropogenic greenhouse gas concentrations.

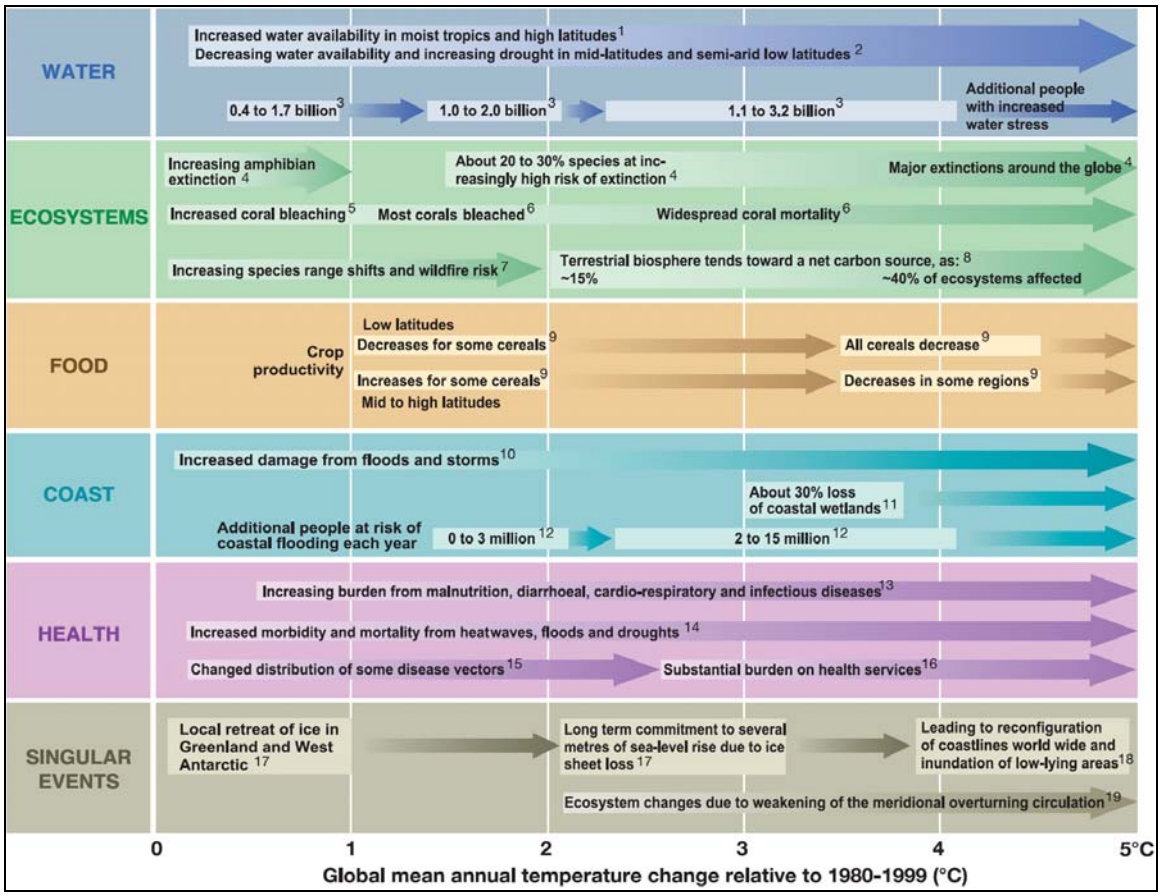
At least 30 scientific societies and academies of science have endorsed the conclusion that global warming is primarily caused by human activities and will continue if greenhouse gas emissions are not reduced. A review of 928 peer-reviewed articles published in academic journals found no disagreement with the consensus view (Oreskes 2004).

Source: Oreskes (2004), IPCC (various years).

A precautionary approach

22. Future global warming will depend on our ability to control the accumulation of greenhouse gases in the atmosphere and limit additional temperature increases. Figure 1 shows the likely impacts that will ensue as temperatures rise. It suggests that if total temperatures increase another degree—making the total about 2^{o} C above pre-industrial levels—significant impacts to water, ecosystems, food, coasts, and human health are likely.

Figure 1 Additional temperature increases possible this century and associated impacts



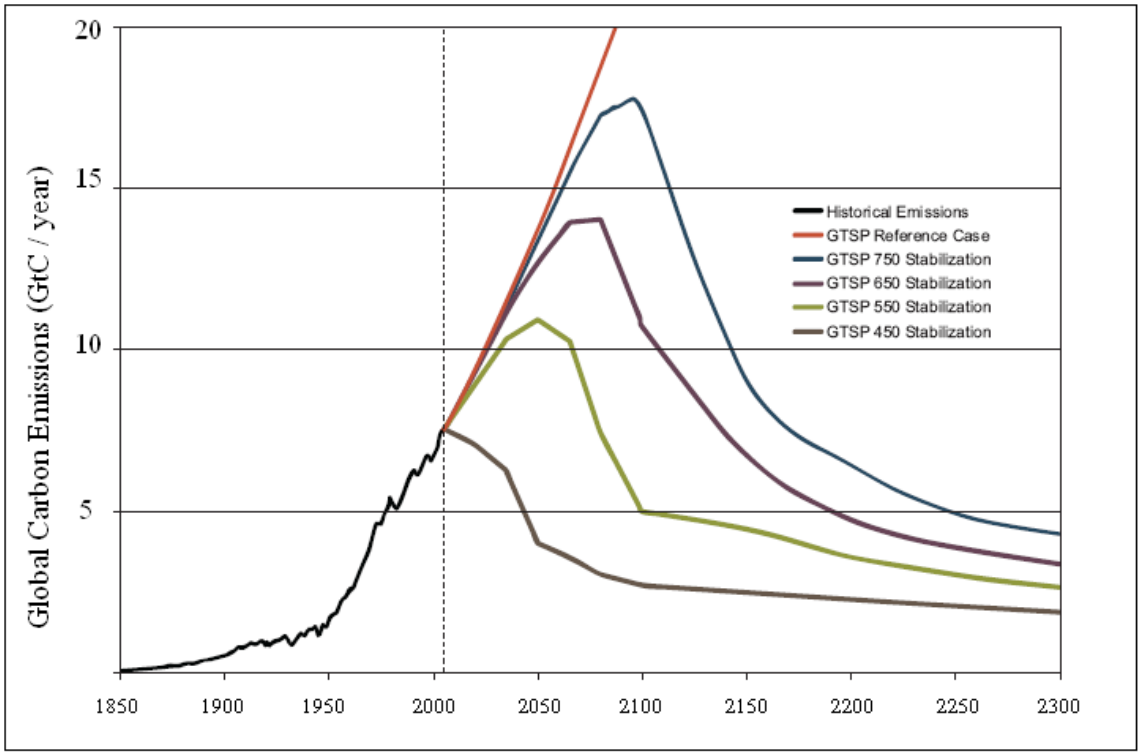
Source: IPCC 2007e. This figure illustrates examples of impacts associated with different levels of global average surface temperature change. The first word of the text describing a given impact is lined up with the mean temperature level (on the horizontal axis) at which onset of that effect is expected. Arrows from one entry to the next indicate increasing intensity and transforming implications of a particular impact as temperature rises. Note that all temperature increases are in addition to the 0.8ºC observed already. To look at references, please visit the technical summary, http://www.ipcc-wg2.org/.

23. A growing number of scientists argue that we should not allow global temperatures to rise by more than 2ºC to 2.5ºC total above pre-industrial levels (European Commission 2007; UNSEG 2007; International Scientific Steering Committee 2005). Ecosystems are particularly vulnerable, and even if warming can be constrained within this range, 20–40 percent of species could face extinction. Crop productivity could be sharply reduced in both the temperate and tropical zones. Greater warming could trigger abrupt and irreversible changes, such as the thawing of the permafrost, which would result in the release of massive quantities of carbon dioxide and methane currently contained in the soil. Another danger is the melting of the Greenland and West Antarctic ice-sheets, which would cause a multi-meter rise in sea level.

24. Without significant changes in emissions worldwide, concentrations of CO_2 will soar past 750 ppm, heading toward a tripling or quadrupling of preindustrial levels (figure 2), and temperatures could rise more than 6°C this century. Such levels would be higher

than have been seen on the planet for millions of years; the speed of change would exceed anything humans or ecosystems have had to adapt to over the last 10,000 years.

Figure 2 Emission trajectories to achieve different atmospheric concentrations



Source: Edmonds et al. 2007. Global CO_2 emissions paths generated by Global Energy Technology Strategy Program (GTSP): historical emissions to 2005, a reference case (i.e., no emissions-control policies), and four alternative paths that illustrate how emissions must eventually decline in order to stabilize CO_2 concentrations at 750, 650, 550, and 450 ppm.

25. The world must develop adequate, achievable, and acceptable goals to confront climate change (box 3). Many have concluded that a precautionary approach entails stabilizing greenhouse gas concentrations at no more than 450 ppm over this century, a level with a 50 percent likelihood of limiting total temperature increase to 2ºC above pre-industrial levels (IPCC 2007a).

Box 3 Adequate, achievable, and acceptable

It is not the role of this report to define the "right" goal for climate talks or for climate policy more generally. Instead, like others, we argue that the goal or target adopted (in terms of GHG concentration or maximum temperature increase) must be *adequate* in terms of offering reasonable assurance that the world is not headed toward irreversible catastrophes; *achievable* in the technical feasibility sense; and *acceptable* in the sense of being efficient, cost-effective, and equitable. Science and engineering can help us define adequacy and what is technically achievable; a combination of economics and politics are needed to identify what is acceptable. Finding a goal that satisfies all three dimensions is no small matter.

26. A goal of less than 450 ppm is environmentally desirable, but even 450 ppm would likely be hugely expensive and may not, in fact, be technically feasible as there is little time for emerging technologies to mature. A 450 ppm scenario would require

emissions to peak no later than 2015, and then decrease by about 50–85 percent below 2000 levels by mid-century (IPCC 2007a). Almost all the world's electricity production will need to have been decarbonized, while emissions from transport, land use, buildings and industry will need to have been cut sharply (IEA 2008). This could require additional annual investments of about US$45 trillion from now to 2050 or about 1 percent of global GDP each year (IEA 2008). This scenario implies a very rapid change of direction and calls for urgent implementation of unprecedented and far-reaching new policies.

27. A 550 ppm CO_2 is associated with a 50 percent chance of warming exceeding a total of 3ºC and a significant probability of exceeding 4ºC. The likelihood of significant and irreversible changes increases at these temperatures, and substantial adaptation costs would be incurred. For GHG concentrations not to exceed 550 ppm, emissions would need to peak and then decrease to current levels by mid-century, continuing to fall substantially thereafter. This would require the adoption of a wide range of technologies that already exist or are in an advanced stage of development, requiring additional investments in the energy sector of about US$17 trillion between now and 2050—roughly equivalent to 0.4 percent of global GDP each year (IEA 2008).

28. A critical question is how the burden of emission reductions should be shared between countries. For example, the 450 ppm scenario would require reducing global emissions per capita to 2 tons by 2050 from the current worldwide average of 7. The 550 ppm scenario instead entails reducing per capita emissions to 5 tons CO_2 by 2050. For comparison, the United States and Canada currently emit around 20 tons per capita, other G-8 countries 10 tons, China 5 tons, India 2 tons and the least-developed countries less than half a ton.

Rich vs. poor or cooperation?

29. Today's global warming was caused in good part by emissions from rich countries. This supports the argument that rich countries should be the ones to lead in reducing emissions (particularly given their significantly higher per capita emissions) and to compensate developing countries for the additional mitigation and adaptation costs they need to incur within lower incomes and capacity. OECD countries' much greater financial and technology resources further argue in favor of their taking on the bulk of the mitigation burden. These points are all embodied in the UNFCCC principle of "common but differentiated responsibilities."

30. However, emission reductions on the part of rich countries will simply not be enough. Energy-related annual carbon dioxide emissions in middle-income countries today are exceeding those of rich countries, and the largest share of current land-use related emissions comes from tropical countries.[3] An important distinction should be made between low- and middle-income countries, as the poorer countries' share remains negligible. More important, projected changes in fossil fuel combustion in middle-income

[3] According to the IEA (2008), non-OECD countries reached the same level of annual energy-related emissions as OECD countries in 2004 (approx. 13 Gt CO_2/year). The World Resource Institute's CAIT emission indicator database suggests the same conclusion using the World Bank's definition of developed and developing countries (WRI 2008).

countries suggest that their CO_2 emissions will continue to increase and will exceed the cumulative emissions of developed countries in the coming decades.

31. The implication, then, is that, as stated in the Bali Action Plan, all nations must play an active role in working toward an agreement that delivers effective steps toward global emission reductions. Rich countries must take the leadership to meet significant reduction targets first, and assist developing countries in rapidly achieving the MDGs while finding lower-carbon pathways and meeting their adaptation needs. Preventing dangerous levels of climate change means there is no more time for delay, and all countries must be part of the solution, starting now.

Providing climate finance to developing countries is not a zero-sum game

32. Estimates of the global cost of mitigation usually assume that mitigation will happen wherever or whenever it is cheapest to do so. Since developing countries have the lower marginal abatement costs, the global least-cost mitigation path is one in which the bulk of mitigation happens in developing countries. Conversely, a climate deal that is based on delayed action by developing countries implies a much higher global mitigation cost for any given target. For example, delaying action to 2050 for developing countries could more than double the cost (Box 4). The reason for this is the increased proportion of mitigation efforts falling on industrialized or so-called Annex I countries with binding emission reduction targets (who have higher marginal abatement costs).[4]

33. The increase in global mitigation cost resulting from a partial climate deal involving only industrialized countries would be borne entirely by these countries. This implies that it is in their economic interest to create incentives for all countries to start mitigating as soon as possible. (The point holds true as long as industrialized countries are genuinely committed to a mitigation target.) A key point in this analysis is that these increases in global abatement costs represent pure *deadweight losses*—wasted additional costs that yield zero welfare gains.

34. The incentive for a global deal therefore exists. As shown in Box 4, developed countries have the option of transferring sufficient finance to non-Annex I countries to make them indifferent between committing to targets in 2012 and delaying commitment to 2020 with phased carbon taxes. The scenarios suggest that, on average, each dollar transferred could yield three dollars in welfare gains to developed countries by eliminating deadweight losses—this is not a zero-sum game.

[4] Annex I Parties are the countries included in Annex I of the United Nations Framework Convention on Climate Change (UNFCCC) that have committed to return their greenhouse-gas emissions to 1990 levels by the year 2000 and have accepted, under the Kyoto Protocol, emissions targets for the period 2008–12. They include the 24 original OECD members, the European Union, and 14 countries with economies in transition. The United States, although a signatory to the Kyoto Protocol, did not ratify the Protocol, and has no binding target. Non-Annex I Parties are the countries that have ratified or acceded to the UNFCCC but are not included in Annex I of the Convention (i.e., they are presently not expected to reduce emissions through the Convention).

Box 4 Assessing deadweight losses from delayed accession to a climate deal

Edmonds et al. (2008) model the costs of stabilizing GHG concentrations in the atmosphere under different regimes: the first assumes that all countries adopt the same carbon price so that mitigation happens wherever and whenever it is cheapest to do so; other regimes have developing countries (so called "non-Annex I" countries) delaying emission reductions.

GHG stabilization costs for a 550 ppm target, relative to global least cost

Scenario	Global cost	Annex I countries share of costs	Other countries share of costs	Annex I cost	Other countries cost
Immediate action by all countries	$1.00	0.28	0.72	$0.28	$0.72
Phased participation by Non-annex I countries					
Delayed introduction to 2020	$1.47	0.62	0.38	$0.91	$0.56
Delayed introduction to 2035	$1.69	0.66	0.34	$1.12	$0.57
Delayed introduction to 2050	$2.39	0.72	0.28	$1.72	$0.67

Source: Derived from tables 2 and 3 of Edmonds et al. (2008).

Table 1 summarizes the cost implications of different policy regimes. All mitigation costs are reported relative to the global least cost scenario normalized to $1—these are present value costs, using a 5 percent discount rate[5]. Because the delayed participation of non-Annex I countries requires Annex I countries to abate more, and these countries have the highest abatement costs, delayed participation results in an increase in the global cost of stabilization. However, it does result in a much lower absolute cost and relative share for developing countries. The cost is therefore entirely borne by Annex I countries. Edmonds et al. (2008) shows this result to hold for different targets (450 ppm and 650 ppm) and whether the application of the carbon prices is gradual or immediate upon its introduction.

Table 1 says that the cost of delaying the date at which non-Annex I countries commit to measurable participation in global action is very high—a 47 percent increase in the global cost of mitigation in the case of the 'best' regime for non-Annex I countries (the scenario with the least cost, delayed participation to 2020), all of which is borne by developed countries. These excess costs are also unnecessary: adopting a universal carbon tax, combined with a transfer of 16 percent of global mitigation costs from Annex I to non-Annex I countries, would achieve the least cost of mitigation for the latter, while eliminating the 47 percent deadweight loss borne by the former.

The Edmonds et al. (2008) model offer a quantification of a result that is robust to all assumptions and simplifications made in the model: if Annex I countries have a firm commitment to achieving particular targets, it is in their interest to create incentives for other countries to join. This is driven by the simple fact that mitigation options are cheaper in developing countries, a point on which all analysts agree.

[5] Because Edmonds et al. (2008) are modeling the least cost to achieve a given GHG concentration, rather than optimal climate mitigation, the path for costs is relatively insensitive to the choice of discount rate.

The cost of action vs. the cost of inaction

35. The question that dominates economic debates about climate change is whether the world should act aggressively now to cut emissions or wait for some future date when more and better technologies are available and people richer (hence, better able to sacrifice income or growth to lower emissions). This debate has been particularly virulent since the publication of the *Stern Review of the Economics of Climate Change* in 2006 and has focused on a particular parameter: the value attributed to the discount rate. Stern (2006) uses a zero rate of time preference (one of two determinants of the overall discount rate) arguing that there is no ethical justification for valuing the welfare of future generations any less than that of today. This implies an overall discount rate that is much lower than that of most other analysts, hence a relatively equal weighing of current and future losses.

36. The reality, however, is that the call for rapid action is not in fact solely dependent on a low discount rate. Instead, many reasonable combinations of assumptions conclude with a convincing case for action (box 5). Such assumptions include the possibility of catastrophic damage resulting from unabated climate change, as in the model of Weitzman (2007), and the increase in relative prices of environmentally related goods whose supply is reduced when climate changes, as in Sterner and Persson (2007). Others (Ambrosi et al. 2003) specifically model the fact that inertia in human and natural systems makes it very costly to reverse course and allow for the possibility of thresholds that should not be overstepped. Some researchers, however, argue that the likely impacts of climate change will be relatively modest—a conclusion that relies on the combination of a moderate discount rate, technological optimism, and bounded damages in their models—which reduces the need for early action (Nordhaus 2007; Tol 2008).

37. The position of the WDR is that ethics, inertia and irreversibility all argue in favor or a precautionary approach to climate change. This approach is in line with the principles of the United Nations Framework Convention on Climate Change.

Box 5 The convincing case for action

The debate among economists about the case for mitigating climate change has centered on the choice of one model parameter—the pure rate of time preference, a component of the discount rate. However, as a meta-review by Heal (2008) shows, time preference is just one of a number of important model assumptions and does not drive the results of whether to take decisive action to mitigate climate change. In fact, even with significant disagreement about the pure rate of time preference and four other key parameters, most combinations—and all those that can be considered reasonable—make a strong economic case for action on climate change.

Heal's (2008) analysis identifies five relevant differences among leading economic discussions of climate change. The choice of a pure rate of time preference, which has received the most attention, is ultimately an ethical one; any rate greater than zero implies that consumption by our generation is more valuable than consumption by future generations, even if they are no wealthier than us—weakening the case for costly mitigation now to protect future generations from harm. Stern (2006) is among the most prominent to stake an ethical claim against this choice, instead opting for a rate of zero. Many disagree with this position (see Yohe and Tol 2008 for a review of the arguments).

Much less contentious is the elasticity of the marginal utility of consumption. A higher elasticity implies that richer generations (likely in the future) should shoulder the burden of climate change. A higher elasticity makes for a weaker case for action.

A more intuitive driver of the results is the modeler's assessment of the cost of the physical impacts of climate change—the higher that costs, the stronger the argument for mitigation. Another related element is whether the economic costs of damage to ecosystem services are included in the impact assessment (a consideration unique to Sterner and Persson 2007, among the mainstream models). Finally, an additional factor, advocated by Weitzman (2007) captures the risk of catastrophic destruction of physical and human systems. In particular, our uncertainty about the size and likelihood of such events argues for adherence to "the precautionary principle," i.e. spending more to mitigate than we would otherwise, in order to stay out of the extreme tail of the distribution of possible impacts.

The estimate of modest impacts, including a high assumed ability of adaptation to reduce these impacts, combined with a downplaying of ecosystem services and catastrophic risk, are the factors which, *in combination* with the high rate of time preference, drive Nordhaus' (1993, 2007) result. Despite the range of approaches to estimating the benefits of action, and despite the choice of quite different pure rates of time preference, the other models—all with reasonable combinations of assumptions—cluster around the same result: the economically sensible position is to act.

	Stern	Nordhaus	Sterner & Persson	Weitzman
Cost of physical impacts	**High**	Low	—	**High**
Ecosystem services	No	No	**Yes**	No
Risk of catastrophe	No	No	No	**Yes**
Elasticity of marginal utility of consumption	1	1	1	2
Pure rate of time preference	**0**	3	3	2
Case for strong mitigation action	Yes	No	Yes	Yes

Proposed structure of the Report

38. The Report will be organized in two parts and include an introductory and a concluding chapter. The introductory chapter will make a case for global action, reviewing the evidence on climate risk and development and discussing how climate change is threatening sustainable development by affecting growth, equity, and environmental sustainability. Part one will focus on what climate-wise development policy could look like, taking an integrated look at mitigation and adaptation challenges and opportunities confronting developing countries. Part Two of the Report will analyze options for a supporting international architecture for mitigation, adaptation, and innovation—the foundations for the development-wise climate policies mentioned above. A concluding chapter will look at the political economy of climate-wise decision making. Like all WDRs the Report will have a stand-alone overview.

OUTLINE

Chapter 1. Why care? Climate Change and Development are Inextricably Linked

PART I. THE CHALLENGES AND OPPORTUNITIES OF CLIMATE-WISE DEVELOPMENT

Chapter 2. Managing Competing Demands and Creating New Opportunities: the Water and Land Challenge

Chapter 3. Managing Competing Objectives and Creating a New Competitive Advantage: the Energy Challenge

Chapter 4. Managing Human Vulnerability: Helping People Help Themselves

PART II. THE CHALLENGES AND OPPORTUNITIES OF DEVELOPMENT-WISE CLIMATE POLICY

Chapter 5. An International Architecture for Climate Change and Development

Chapter 6. Harnessing Finance and Market Instruments for Mitigation and Adaptation

Chapter 7. Harnessing Innovation and Technology Diffusion for Mitigation and Adaptation

Chapter 8. What Next? Achieving Climate-Wise Decisions

39. The team is benefiting from an extensive consultation process, both within and outside the World Bank. The WDR team has carried out consultations with a panel of external academic advisers, with NGOs, donor agencies and foundations, government officials from OECD countries, as well as the Philippines and China. Future consultations are planned in Bangladesh, Brazil, China, Egypt, Indonesia, Japan, Mexico, Morocco, Russia, Senegal, South Africa, Vietnam, and in the context of UNFCCC events (Poznan). Workshops are scheduled in Thailand and South Africa to consult with authors of National Adaptation Programmes of Action (NAPAs) from ten to twenty countries in East Asia and Africa. The WDR team will also rely on a blog as an online consultation tool.

Chapter 1 Climate change and development are inextricably linked

1.1 This chapter will look at what climate change means for development, starting from a consideration of the current state of development challenges and achievements. The analysis will combine the climate change, social development, poverty, and disaster risk literatures on vulnerability. It will summarize the emerging scientific consensus on what targets may be *adequate* to avoid irreversible losses and dangerous climate change and discuss what is actually *achievable* in terms of timely reduction of greenhouse gases (though the detailed discussion of land use and energy pathways will be developed in chapters 2 and 3). It will review how different disciplines (e.g., ethics, international law,

and economics) can help define what is *acceptable*. The chapter will conclude with a discussion of the possible development opportunities associated with a push for lower-carbon and more sustainable growth paths.

1.2 The likely messages are:

- *Development progress is threatened and may be reversed without firm action to manage climate risks*. Climate change is inextricably linked with development, but presents new challenges because of its global nature, the magnitude, and irreversibility of its impacts, its intergenerational dimension. Climate change will exacerbate poverty and inequality and compromise the advance of human rights and social justice for the poorest and most vulnerable. Evidence shows that the poor are very vulnerable to exactly the sorts of climate shifts, policy interventions, and other shocks that will be engendered by climate change. The case for action is strong, whether considered from the perspective of science, economics, ethics, or international law.

- *However, climate change is one of many development challenges.* Developing countries' overriding priorities are increased prosperity and the sustainable reduction of poverty and inequality. In the longer term, these goals cannot be achieved without managing climate change. But policies to tackle climate change must factor in the reality that sustainable development faces many other immediate and dramatic challenges.

- *Developing countries need room to grow, but growth alone will not eliminate climate risk.* Growth will neither be sufficiently far-reaching, nor rapid enough to provide the poorest countries or citizens with resources sufficient to manage the impacts of climate change. Additional targeted adaptation efforts will be needed—notably the mal-adaptation that can occur with growth and prosperity (such as increased settlement of coastal zones and flood plains). And adaptation has its limits. It can not protect against the catastrophic physical and economic impacts of unchecked climate change. To prevent climatic changes with dangerous welfare consequences, all countries will need to mitigate emissions of greenhouse gases, under the guiding principle of common but differentiated responsibilities, with attention to the need for continued poverty reduction.

- *While climate change and climate policies will impose costs on all countries, they could also create new opportunities.* Climate change is altering the global competitive landscape, creating new markets and momentum for reform. This can create opportunities to jump ahead to new solutions rather than follow the path through old technologies; recalibrate policies; and raise new financial resources for mitigation and long-needed adaptation. But opportunities have to be seized, which requires vision and leadership.

Development is, and will be, threatened by climate change

1.3 Few countries are well adapted even to today's climate, and this will be worsened by climate change. Vulnerability varies based on income and the quality of institutions, though even rich countries make bad choices (e.g. building on flood plains or in hurricane paths). Vulnerability is also determined by the degree of dependence on natural capital and exposure to multiple stressors. Welfare losses associated with climate change are likely to be much greater for poor countries and poor people, worsening intra- and international inequality. The intersection of poverty with old age, gender disadvantage, and/or ethnic minority status, for example, can leave people particularly exposed to shocks and unequipped with the human, social, and physical capital necessary for recovery. The chapter will use a measure of vulnerability that includes a measure of welfare (as used in the poverty literature) but that can be clearly linked to the definitions of vulnerability used by the climate community. The chapter will look at welfare in the short, medium, and long term.

1.4 Climate change implies changing means, increasing variability and worsening extremes, all of which impact the pillars of sustainable development: growth, equity, and social and environmental sustainability. But policies to tackle climate change will also affect growth, equity, and sustainability, with the direction of the impact determined by how the policies are designed. Such policies include internationally-driven carbon labeling of traded goods, biofuels and carbon sequestration forests, domestic implementation of green growth strategies, and associated price changes in global and local markets (for food, transport, utilities, as well as labor). This discussion will highlight the fact that growth—while a continued priority for developing countries—is not in itself an answer to climate change. Even without climate change, phenomena such as high energy prices, local pollution, and stressed water supplies require renewed assessment of the sustainability of current development paths. Climate change makes this reassessment all the more urgent.

The case for action

1.5 The uncertainties around climate change have been exaggerated and misunderstood; they constitute a case for action and not an excuse for inaction. Despite uncertainties there is enough information to guide climate resilient practices. The process of climate change includes dangerous and irreversible effects. Adherence to the precautionary principle in order to avoid catastrophic risks requires stabilization of global atmospheric concentrations at levels at least as low as 450–550 ppm CO_2e. The chapter will address the need to bend the curve of the global emissions trajectory and set the stage for a later discussion (in chapter 3) of who mitigates, how, and when.

1.6 The chapter will also emphasize the importance of halting climate change and sustaining ecosystems and biodiversity not only for their own sake, but because of their critical importance in sustaining livelihoods, human health, and social and economic systems. Human welfare remains the key goal of development. However, a complete definition of welfare includes dimensions that go beyond income and what is priced. Ecosystems are critical components, notably for their contribution to health and nutrition,

cultural tradition, and physical security—all of which may be threatened by climate impacts and policies. Disparate disciplines and agendas therefore converge around the need for strong, global action to combat the sources and impacts of climate change.

1.7 The chapter will review what different disciplines (ethics, international law and economics) suggest are appropriate policy responses given the scientific evidence on climate change and its likely impacts. It will also develop the argument mentioned above that it is in the financial interest of high income countries to facilitate rapid mitigation in emerging economies—a point that could help accelerate transfer of resources and technologies to these countries.

A vision: climate change as an opportunity

1.8 Climate change alters the competitive landscape of the world. This will cause losses, but also create opportunities. Recognizing this and taking the right steps can ensure that the new opportunities benefit developing countries. On international markets, for example, some developing countries will have comparative advantage in the production of wind and solar energy or sustainable production of biofuels. Further, infrastructure investments informed by climate priorities and supported by new climate financing may be well suited for achieving primary development goals. Developing countries could benefit from greater access to dedicated financing for leapfrogging to modes of building, transport, and energy that minimize financial and physical resource requirements, thereby reducing initial and long-term costs.

1.9 Climate change may also help create a momentum for reform on critical agendas, such as: (i) more efficient or sustainable economic growth through better natural resource management and more efficient use/pricing of energy and water; (ii) scaling up technologies that have great advantages for developing countries (off-grid energy provision, desalination plants, new vaccines); (iii) increased attention to and improved preparedness for disaster risk reduction. The discussion will consider past experience to identify the circumstances in which local disasters and international challenges have catalyzed lasting reform and well planned investments (e.g. Brazil, Denmark, and Japan's response to the 1974 oil shock).[6] New resources from mitigation and adaptation finance will be critical to sustain momentum around these innovations.

[6] Policy change is usually slow, gradual and superficial. However, shocks such as massive and sudden changes in socioeconomic conditions or a catastrophe can lead to substantial and rapid policy change—though this is not automatic. A fairly well developed political economy literature exists that analyzes the circumstances under which shocks are transformative (Birkland 2006; Sabatier and Weible 2007).

Part I The challenges and opportunities of climate-wise development

Chapter 2 Managing competing demands and creating new opportunities: the water and land challenge

2.1 This chapter will examine how climate change complicates the already challenging task of managing water and land resources. It will take an integrated look at how climate change increases the pressure on resources created by the competing demands that development and population growth place upon water and land. The chapter will examine the implications for agriculture, forestry, fisheries, and biodiversity; it will discuss the operational realities of putting some of the potential adaptation and mitigation solutions into practice, their trade-offs, their synergies and some of the opportunities that climate change may create.

2.2 The likely messages are:

- *Climate change will add to existing pressures on land and water, making them harder to manage, with potentially devastating impacts for development.* Water and land are already strained resources. Climate change will affect the availability of water and impact ecosystems, thereby creating new and competing demands for water and land, with adverse consequences for food security, poverty, and social stability.

- *Many solutions exist for specific resource management problems—some old, some new, some gradual, some transformative—but to be effective in a greenhouse world, solutions will need to be integrated across sectors.* Improved policies, incentives, and investments, and new technologies can reduce competition for land and water, but solutions require integrated assessment and implementation across social and economic sectors.

- *Climate change could be a catalyst for overcoming the political and institutional barriers that have proved insurmountable in the past.* Land and water issues are usually highly politicized and suffer from poorly performing institutional arrangements. In some cases, climate change may create political momentum for reform, or bring new resources to elicit improvements in governance and institutions.

Climate change will make land and water harder to manage

2.3 Climate change will add new stresses to ecosystems and biodiversity, with potentially devastating impacts on food security, energy security, and the delivery of environmental services. Change will take place faster than the ability of many natural systems to respond, and there is potential for major collapses as threshold and tipping points are reached. Land, freshwater, and ocean-based food production will become less reliable because of the combination of growing pressures on resources (such as

population growth, greater affluence and urbanization, habitat transformation, and higher pollution) and global warming (changes in temperatures and in the hydrological cycle).

2.4 Mitigation policies will increase demands on water—and in some cases land—as they lead to more calls for afforestation and reforestation, biofuels, and non-fossil-fuel energy sources (hydroelectricity and nuclear), even as many countries will need to allocate more resources (again, water, and land) to food production. Many models predict that these demands will cause a sharp decrease in 'unmanaged' land. The endangerment of natural habitats and biodiversity will further imperil the poorest, and it is in conflict with rising adaptation needs, often requiring protection through the restoration of flood plains, mangroves, and coastal habitats.

Answers exist to specific problems but multi-dimensional problems need integrated solutions

2.5 Many potential solutions to individual resource management problems exist, and some new potentially transformative solutions are on the horizon. Some of the solutions are institutional (e.g. adaptive management, better monitoring, and better enforcement of regulations), some are economic (e.g. removing subsidies that encourage over-exploitation of resources, or finding incentives for large-scale private investment in conservation), some involve advances in the design and operation of major infrastructures (e.g. dams), and some involve new technologies (e.g. biotechnology for the production of crop varieties more resistant to climate-related stresses).

2.6 However, a potential solution to one part of the resource management problem (e.g. ensuring water supply for a coastal city through desalination of brackish water) may worsen another problem (energy-intensive desalination may increase carbon emissions, and the brine discharges could disrupt coastal fisheries). This will often result in difficult trade-offs. In addition, decisions today can lock communities or individuals into patterns that are not sustainable in the long term. Climate-wise approaches will need to be forward-looking and take on the changing environment by providing transboundary solutions, both at the landscape and cross-sectoral level. Systemic changes will also be needed, going far beyond natural resource management, such as the reform of the world agricultural trading system and new paradigms for international technology and knowledge transfer.

Climate change could help break longstanding deadlocks

2.7 Many of the actions that will allow the best management of land and water resources are those that development practitioners have been advocating for decades but which have proven institutionally or politically difficult to put into practice. To finally overcome this barrier will require solving some of the most perennially resistant development challenges relating to governance and institutional capacity. The ability of individuals and governments in developing countries to manage these challenges will depend on institutional and governance factors as much as technical solutions.

2.8 Climate change could be a catalyst for overcoming some of the barriers that have been insurmountable in the past. By creating increasing urgency, climate change may help mobilize the financial, political and knowledge impetus needed for countries to overcome barriers to change, and stimulate innovations to reduce policy trade-offs and improve institutions. For example, ongoing changes in forestry policies (decentralization, creation of new forest commons) combined with improved remote sensing monitoring technologies are creating new opportunities for many developing countries to lead in and benefit from an emerging Reducing Emissions from Deforestation and forest Degradation (REDD) architecture. Such changes will help countries demonstrate the role of their forestry policies in the co-generation of livelihoods, biodiversity, and carbon benefits from forests.

2.9 However, in most countries, the existing political economy and institutional incentives stack the deck against goods and services that do not bring short-term benefits to influential groups. This is particularly true for biodiversity preservation. To avoid biodiversity "losing" the increasingly tough competition for land and water resources, policy makers nationally and internationally will need to publicize the critical importance of conservation and resource protection to human well-being and to the longer term sustainability of food production systems. Positive examples exist of outcomes in which collapse is avoided, but the challenges will increase and require additional efforts to resolve the issues.

Chapter 3 Managing competing objectives and creating new opportunities: the energy challenge

3.1 This chapter will discuss how to reconcile competing objectives for energy policy. It will outline clean-energy technology options, mitigation paths and timelines that major economies would need to follow to reach particular CO_2 stabilization targets. The chapter will also identify country-level policy instruments that can facilitate lower-carbon growth.

3.2 The likely messages are:

- *Traditional carbon-intensive growth is not globally a viable option.* Developing countries need energy to grow and to expand their reach to the 1.6 billion people without electricity access. Rich countries have economies and lifestyles that are massively carbon intensive. But either group continuing on a business-as-usual path over the coming decades would most likely result in greenhouse-gas concentrations that lead to dangerous impacts and irreversible losses.

- *Significantly lower-carbon growth paths are technically feasible and could create a new competitive advantage for some countries.* Increased efforts to improve energy efficiency and greater use of existing renewable energy technologies would go a long way towards reducing greenhouse gas emissions. A scaling up of emerging technologies could greatly reduce their costs, make them financially competitive, and provide new market opportunities for a number of developing countries (as well

as for some developed countries). But urgent action over the coming decade, by rich and developing countries, is required to avoid world "lock in" to long-lived, high-carbon infrastructures.

- *But lower carbon growth paths are economically and politically challenging and will require a transformative change.* Climate-wise development policies can shape such low-carbon growth paths. Even reforms that "pay for themselves" or those with co-benefits are seldom adopted without additional support (financial, regulatory, informational, and institutional). In the transport and housing sector, lower carbon alternatives require influencing the decisions of a multitude of individuals. Carbon pricing will help, but as witnessed by the unrealized potential for energy efficiency, financial profitability is not always sufficient to trigger change and correct market failures. Thus complementary private and public actions are needed to tackle barriers to change.

Energy, mitigation, and growth: reconciling the adequate and the acceptable

3.3 Energy development is needed to fuel economic growth, increase energy access for the world's poorest, enhance energy security, and improve the local and global environment. Improving energy access for the poorest will not have a significant impact on global emissions.[7] The recent oil price hikes and uncertainty about gas supplies is driving many countries (rich and poor) to build new coal-fired power plants. And, given that the modern growth model is one in which fossil fuel consumption, hence emissions, increases with income, there are clear and valid concerns about whether mitigation is compatible with growth. But a failure to mitigate, leading to a potentially catastrophic impact on development, is equally incompatible with growth. Under a business-as-usual scenario, energy use and energy-related CO_2 emissions would more than double between now to 2050 (IEA, 2008). A rise in CO_2 emissions of such magnitude could raise global temperature by 6 degrees, perhaps more (IPCC, 2007).

Significantly lower-carbon growth paths are technically achievable, but require urgent action

3.4 Decoupling emissions from growth requires economic structural changes, reduced energy intensity, and shift to less carbon intensive fuel mix. Clean energy technology options exist—but vary with respect to technical feasibility, commercial availability, and financial viability. There are distinctive barriers facing low-carbon alternatives for power (where adoption is controlled by a small number of decision-makers), and for transport, buildings, and industry (where adoption is a function of the preferences of, and requires action by, many decentralized individuals). Each sector requires different interventions to remove its unique barriers, and different policy instruments will be needed to encourage adoption of clean energy technologies at various development stages to take technologies from the laboratory bench to commercially available, to financially viable, and eventually to widespread scale-up and deployment.

[7] Meeting basic human needs for both electricity and clean cooking fuel would produce only a three percent increase in global CO_2 emissions relative to current levels (personal communication with Robert Socolow and http://www.environment.harvard.edu/navigation2/Socolow.ppt).

3.5 Existing energy technologies can bridge 70 percent of the emission reductions required to reach 550 ppm (IEA 2008), though reaching the more ambitious goals (e.g., 450 ppm) would require aggressive early adoption of advanced technologies. A portfolio of low-carbon technologies, such as energy efficiency, renewable energy, nuclear, and carbon capture and storage, along with urban and transport planning and lifestyle changes are needed. The chapter will outline possible clean energy mitigation paths for major economies, so as to illustrate what actions would be necessary, and how intense those actions are (and over what time paths) in order to achieve 450 ppm and 550 ppm stabilization levels.

3.6 Action over the coming decade is critical, because infrastructure put in place now in either developed or developing countries will persist for many decades (e.g., energy generation and transmission systems, urban settlements, etc.). Delayed actions have a danger to "lock in" carbon-intensive capital stock that may still be in use by 2050, and could require very costly late adjustments to the energy system. It is particularly important for developed countries to demonstrate leadership in changing their energy systems by "greening" the portfolio of new investments.

Achieving low-carbon growth paths requires challenging and far-reaching reforms

3.7 Externalities associated with greenhouse gas emissions must be reflected in pricing or addressed through regulation. For clean energy technologies to compete against existing greenhouse-gas intensive technologies, it is essential to put a price on carbon and reduce fossil fuel subsidies. However, market pricing alone will not be enough. Policies to encourage the development of clean technology, remove barriers to their adoption, and promote lifestyle changes are also priorities, particularly in developed countries but increasingly in middle-income countries too.

3.8 Options with multiple development benefits do exist, such as energy efficiency, wind power, and methane capture, that offer energy savings, enhanced energy security, reduced local air pollution, and increased job opportunities, which can more than offset costs. However, policy actions, financing, and institutional reforms (which have successfully been used) are needed to remove barriers to their adoption. The private sector has been at the frontier of clean energy business, and can play an even greater role if these enabling frameworks are put in place. Many developing countries have already moved in this direction, but much more is needed.

3.9 However, "win-win" options are not enough, and trade-offs have to be made. Pricing carbon and accelerated technology development and transfer are needed if advanced technologies that are not yet commercially available are to be scaled up. To this end, rich countries should increase efforts both domestically and internationally by providing financial assistance and technology transfer to the developing world. It is also critical to integrate policy, planning, and institutional arrangements for energy, urban development, land use, and transport to reduce reliance on cars, as well as facilitate lifestyle changes. This section will discuss the climate-wise development policy instruments needed to achieve the desired GHG stabilization levels. While technology

and policy options exist, strong political will and unprecedented global cooperation are essential to trigger truly transformative change.

Chapter 4 Managing human vulnerability: helping people help themselves

4.1 This chapter examines the key determinants of risk and vulnerability of people from the household to the national level, discusses historical and ongoing adaptation strategies and their shortcomings, and proposes entry points for public policy to protect people—particularly the poor and those in vulnerable areas—from the adverse effects of climate change and variability. It also addresses how climate change policies can create new opportunities and momentum to better manage risks, reduce systemic vulnerabilities, and avoid potential new threats to people. The starting point for this chapter is an investigation of existing ways of reducing climate vulnerability through autonomous and planned adaptations at multiple levels including social safety nets, management of slow and abrupt-onset climate hazards, risk financing, and early warning systems. These strategies and interventions are critically evaluated with respect to their effectiveness in promoting adaptation and reducing current and future vulnerability.

4.2 The likely messages are:

- *Climate-related risks and vulnerabilities are distributed unevenly across countries and among people within countries.* Global warming manifests itself through changes in means, variance, and extremes of temperature and precipitation. These changes produce differentiated patterns of risks across social groups: changing patterns of rainfall and precipitations as well as droughts, floods, and storms have multiple physical, financial, and social impacts.[8] Low income countries and poorer populations will be especially vulnerable. Their vulnerability is shaped by spatial location (with great variations between urban and rural areas), socio-economic conditions, access to means of adaptation, and compounding of multiple stressors. Targeted strategies and interventions that explicitly account for these differentiated impacts are necessary to protect people from climate-related threats now and in the future, and help them adapt.

- *Strategies to reduce risk and vulnerability need to be systematically integrated in development through public policy***.** To do this, it is important to strengthen new institutions and policies for adaptation, solve political gridlock that prevents effective adaptive responses, improve communication and information systems, remove economic and political disincentives, and implement risk management approaches that delineate public, civic, and private roles and responsibilities. Specific policies are required to address the physical, financial, and socio-cultural

[8] The report will discuss extreme events (slow and rapid-onset) but will emphasize the impact of repeated small events or compound stresses—e.g. a community is not just vulnerable to the large flood or drought of record, but also to the small drought happening the year after the small flood has exhausted reserves.

dimensions of risk and vulnerability through vulnerability reduction, prevention, risk management and recovery assistance.

- *Policies to address climate change provide new opportunities to better cope with existing climate perils, but may also create new threats.* Climate change will compound other major development challenges. Managing climate risks will become critical to the development agenda. Addressing these challenges will require a stronger commitment to social justice and greater attention to distributional and equity concerns in climate governance. Risks arising from climate change policies in particular will need to be addressed explicitly in development strategies and may require substantial means-based transfer mechanisms as well as greater emphasis on climate-related education and awareness building.

Heterogeneous patterns of risk and vulnerability

4.3 Risk and vulnerability are aggregate concepts—put simply, while risk refers to the likelihood and magnitude of a certain impact, vulnerability includes the ability to cope with the negative consequences of such an impact. As such, patterns of risk and vulnerability are determined by the space and time scales of climate impacts, the location of people and their assets in their natural, physical, and economic environment, their sensitivity to impacts, and their ability to respond to climate stress (both individually and collectively). This chapter starts by describing the key determinants of risk and vulnerability at the household, community and national levels. It will focus on the pathways leading to risk and vulnerability, the distributional effects of climate-related threats, and the interaction with development. It will show that the capacity to manage the negative impacts of climate variability and different climate hazards varies significantly across countries and people within countries. Further, there is a significant adaptation deficit in many countries, which needs to be addressed through a combination of institutional, informational, technical, and financial instruments.

Public policy plays a key role in risk management and vulnerability reduction

4.4 There are many traditional as well as innovative approaches to manage risks and reduce vulnerabilities both ex-ante and ex-post, including early warning systems, community-based and national disaster risk management schemes, indigenous adaptive strategies, migration and income diversification, weather-linked insurance, and social safety nets. Few were designed as adaptive measures for climate change. Many are costly or suffer from barriers to wider spread adoption and are therefore not being deployed as a response to climate change. Nonetheless, historical approaches provide a useful starting point to address people's risk and vulnerabilities. Public policy needs to encourage such approaches and strategies where they have proven to be effective, strengthen, scale them up or help reduce their costs where appropriate, and strengthen institutions and mechanisms for adaptation where existing ones prove inadequate.

Climate change policies represent new opportunities but also new challenges and risks for people

4.5 Future climate change policies and associated interventions can affect people's risk and vulnerability in two ways: on the one hand they may provide new opportunities and political momentum that results in better risk management and helps reduce vulnerability; on the other hand they may have negative repercussions for the most vulnerable. For instance, policies to provide financial incentives to avoid or reduce emissions from deforestation may provide new opportunities for forest dwellers to be compensated for good forest stewardship, helping achieve effective mitigation and adaptation simultaneously. But if designed and implemented without care, forestry and bio-energy policies may threaten forest-based livelihoods, biodiversity, and ecosystem functioning.

4.6 Similarly, policies and interventions to provide protection to farmers through insurance can provide new opportunities for financial institutions in rural areas (e.g. increase their client base and diversify their business), but also undermine farmers' incentives to adapt. Climate change as well as climate change policies can affect commodity prices and have negative consequences on the welfare of the poor and vulnerable. Effective policies to address risks and vulnerability will require changes in politics and institutions. The chapter will explicitly explore these two aspects of climate change policy and make concrete policy recommendations grounded in existing experiences.

Part II The challenges and opportunities of development-wise climate policy

Chapter 5 An international architecture for climate change and development

5.1 Our understanding of the challenges posed by climate change has evolved since the early 1990s, when international negotiations established the UNFCCC and subsequently the Kyoto Protocol. The international architecture for addressing these challenges will need to evolve correspondingly. This chapter will review and assess the current architecture's capacity to reconcile climate change and development objectives, and discuss options for its future evolution.

5.2 The likely messages are:

- *The current framework has delivered important lessons, but these are only the first steps.* The future policy architecture will need to go well beyond narrowly defined environmental sustainability concerns, and address fundamental shifts in the way countries achieve growth and well-being. This implies placing development concerns at the heart of a new climate agreement.

- *A more development-oriented climate architecture is needed.* This is a necessary condition for obtaining buy-in from developing countries, and will require factoring development realities into climate agreements. As agreed in the Bali Action Plan, critical elements include identifying mitigation actions consistent with development goals, and providing developing countries with adequate, predictable and sustainable financing and technology support for adaptation and mitigation.

- *An international architecture will be sustained only if participants perceive it as fair.* A fair outcome needs to include a set of equity principles, including responsibility for the problem, capacity to act, equal entitlement and comparability of efforts. However, no single equity perspective or formula can be a basis for an agreement and the goal instead should be a political package that achieves a qualitative balancing of competing equity claims.

The current architecture has delivered important results but remains a first step

5.3 The establishment of the UNFCCC laid the foundations for global action on climate change. The Kyoto Protocol has set limits on GHG emissions in industrialized countries and, through its innovative market instruments, spurred cost-effective mitigation in developing countries as well. Overall, the climate regime has prompted countries to prepare national climate change strategies and to build some needed processes for GHG inventories, policy coordination, reporting and implementation review.

5.4 However, the current climate policy instruments are limited in scope and duration, reducing their effectiveness in addressing the full range of challenges posed by climate change. Further, they provide inadequate incentives and enforcement tools for mitigation action and, until a newly established Adaptation Fund becomes operational and grows, only very limited support for adaptation in the poorest and most vulnerable countries.

An effective climate deal needs to frame development and climate within a single agenda

5.5 The central challenge in strengthening the climate policy architecture is establishing a set of equitable commitments and incentives that facilitate timely and ambitious efforts in mitigation, reduction of impacts and support for adaptation. The building blocks, as provided by the Bali Action Plan, include leadership by developed countries in committing to emission reduction goals, mechanisms for the growth of the global GHG market, and the provision of technology, finance, and adaptation support to developing countries.

5.6 To enable the full participation of developing countries, the architecture must advance, not undermine, their development objectives. Many developing countries are already undertaking significant mitigation efforts. Achieving the global emission reductions needed will require further support and incentives for additional efforts—particularly by those countries with large current or projected emissions. National Communications to the UNFCCC and the National Adaptation Plans of Action (NAPA)

developed by many of these countries outline strategies that contribute to GHG mitigation while addressing other critical development objectives. These plans can serve as a basis for defining and recognizing nationally appropriate actions in a new climate agreement.

5.7 Given the strong diversity between and among developed and developing countries, an equitable climate policy will need to accommodate a wide variance in circumstances, capacities, and climate strategies. This requires flexibility in the form, timeframe, and stringency of countries' mitigation actions and commitments.

5.8 Existing market-based mechanisms require reforms to more effectively and efficiently mobilize adequate financing and channel investments towards developing countries. The mitigating potential of reducing emissions from deforestation and degradation (REDD) and other forest related issues has the potential to provide increased opportunities for many developing countries.

5.9 The credibility of the future architecture will play a key function in its effectiveness and sustainability. The UNFCCC Bali Action Plan, agreed by over 180 countries in December 2007, outlines the future framework and puts emphasis on measurement, reporting, and verification, both in assessing mitigation actions in developed countries and in measuring financial and technical flows to developing countries.

Chapter 6 Harnessing finance and market instruments for mitigation and adaptation

6.1 A fair deal on climate change for developing countries will require substantial financial flows, both through fiscal transfers and carbon market transactions. Reforming carbon markets—the trade in greenhouse gas emission reductions—and finding additional finance for adaptation are among the key goals of the current negotiations. Embarking on global emission reductions early would reduce the financial needs substantially.

6.2 The likely messages are:

- *Fairness and finance for climate change are inextricably linked.* Climate change will cost billions, both to curtail emissions and to adapt to the consequences of change. Financial burden-sharing between developed and developing countries must be part of any fair deal on climate change.

- *The exact size of the bill, and the sources of funds, will depend on the structure and timing of any deal on the international climate architecture.* Achieving fairness through fiscal transfers risks donor fatigue, which may favor market solutions such as cap and trade. Delaying emission reductions in developing countries could entail huge deadweight losses, which accentuates the urgency for an agreement on

assistance to developing countries through market-based and concessional finance instruments.

- *Private finance through carbon markets can play a major part in funding mitigation***.** The existing carbon offset markets will likely remain a major source of climate finance for developing countries, making reform of these markets a high priority. The Clean Development Mechanism (CDM) has provided important lessons, but it has bypassed low-income countries and the forest sector.

- *Factoring climate risks into development programs is the core of climate adaptation***.** Finding new sources of adaptation finance, creating transparent mechanisms for allocating it, and packaging it with development finance at the program and project levels are essential for an effective response to the challenge of climate adaptation.

Fairness, finance, and the urgent need to achieve a global deal

6.3 The chapter will start with an indication of the funding likely to be required for a fair and effective global deal. The chapter will summarize the mitigation and adaptation cost figures currently offered in the literature, including results from the World Bank, the UNFCCC, the Stern Review and various global models. At the high end these estimates surpass the US$ 100 billion mark, suggesting that the additional finance required might be on a par with current ODA flows.

6.4 The chapter will then analyze how the magnitude and provenance of financial flows—both investment and development assistance—depend on the international climate architecture. Delayed action by developing countries, harmonized taxes, and cap and trade schemes all offer alternative routes to achieving fairness for developing countries, with distinctive costs and advantages. In addition, financial flows to some countries could be large enough to raise issues of the effective management of these flows, including avoiding 'Dutch disease' effects.

Mitigation: scaling up private finance through carbon markets

6.5 On mitigation, the chapter will argue that the lion's share of finance can and should come from the private sector, primarily through carbon markets and investment in low-carbon technology. However, public funds and public policy have an important complementary role to play by providing public goods, correcting market failures and establishing a business environment conducive for low-carbon investment.

6.6 For developing countries, the most likely source of carbon finance over the medium term will continue to be one sided "baseline and credit" schemes like the CDM. The chapter will analyze to what extent the CDM is delivering: while the global benefits in terms of emissions reductions achieved will be mentioned, the main focus will be on the local benefits the CDM brings to developing countries. There are three broad categories of host country benefits: financial flows, technology transfer and contributions to local environmental sustainability.

6.7 The chapter will then investigate ways to scale up CDM delivery—either through CDM reform or a parallel mechanism—to the level ultimately required, which could be an order of magnitude higher than today. Options include programmatic approaches, sector-based approaches, the bundling of projects, expanding the role of REDD, and streamlining the regulatory process without compromising project quality. A particular focus will be on ways to open the carbon market to low-income countries, where dealing with emissions from land and deforestation could yield important development co-benefits—rectifying policy and institutional weaknesses in these countries will be essential if they are to participate more widely in carbon markets.

Financing adaptation: new finance, transparent allocation, effective integration with development efforts

6.8 A key aspect of effectiveness is that adaptation finance must be used in an integrated manner with other development finance—in a greenhouse world, adaptation has many overlaps with good development.[9] The chapter will review and discuss alternative sources of adaptation finance. A widely proposed measure for adaptation finance is a levy on carbon offsets or emissions trading in general. A 2 percent tax on most CDM transactions is the main financing source for the Adaptation Fund. However, this entails taxing a substitute for adaptation and will engender deadweight losses, which will be analyzed.

6.9 The chapter will also discuss possibilities to leverage private finance, for example through catastrophe bonds or by building adaptation infrastructure through public-private partnerships. There is a growing understanding about the opportunities and risks of private sector participation in infrastructure, which can have a bearing on the scope of involving private investors (and operators) in adaptation infrastructure.

6.10 With adaptation finance likely to be in high demand, the effective allocation of limited adaptation funds will be a key challenge. The chapter will report on research combining indicators of effectiveness and need. The discussion of effectiveness will draw on the Bank's experience in allocating IDA resources and the literature on aid effectiveness. To address the question of need, the chapter will develop an index of climate change sensitivity, likely to cover agricultural, coastal and health impacts, as well as exposure to extreme weather events.

[9] The accounting for the "new and additional finance resources" under the UNFCCC is currently being debated by the negotiators. Many argue that these contributions must be clearly distinguished from ODA and other forms of development assistance. It is not the role of the WDR to engage in this debate but it will treat the issues associated with the effective integration of new climate related resources and existing development finance.

Chapter 7 Harnessing innovation and technology diffusion for mitigation and adaptation

7.1 The chapter will examine the role and implications of innovation and technology diffusion for responding to climate change and will provide recommendations for enhancing the scope, reach, and effectiveness of research, development, demonstration, and deployment (RDD&D) of climate-wise technologies. Unprecedented international efforts in innovation and diffusion of climate-wise technologies will be needed both to prevent unmanageable climate change and to cope with unavoidable impacts on society.

7.2 The likely messages are:

- *There are significant barriers to the diffusion of available climate-wise technologies, particularly in developing countries.* The diffusion of climate-wise technologies suffers from a number of market and policy failures that curtail their rapid deployment. Low technological absorptive capacities and a lack of complementary technological assets compound this problem even further in developing countries.

- *World investments in research, development, demonstration, and deployment of climate change mitigation and adaptation technologies must be significantly increased to spur needed levels of innovation.* Estimates of the deployment of clean energy technology needed to meet a 450 or 550 ppm target exceed historic rates of penetration and innovation. Climate changes already underway will lead to stresses exceeding infrastructure and species tolerances, requiring innovation in management, planning, monitoring, ownership and insurance regimes.

- *Innovation in mitigation and adaptation options must be reinforcing and enhance sustainable development.* Particularly promising areas for synergies are in agriculture, biofuels, forestry and water management, and disaster preparedness and response. New energy crops, low-water consuming non-fossil energy sources, carbon-conserving tillage and forestry regimes, and institutions and infrastructure that withstand climate shocks can facilitate both mitigation and adaptation. National technological capabilities gained from tackling mitigation and adaptation challenges will have positive spillovers on economy-wide technological progress.

- *Rapid development and deployment of the next generation of clean energy technologies requires integrated public and private sector policies, international cooperation and North-South and South-South technology transfer*. Effective policies should consider all players and interconnections in the innovation process. Moreover, some challenges are too difficult to tackle at the national level and will require international collective action, particularly to help developing countries identify, adopt, adapt and improve existing technologies.

Innovation does not occur in isolation but must be understood as a systemic process

7.3 The chapter will present current global efforts related to innovation of climate-wise technologies, in both developed and developing countries, and contrast them to what is required to address challenges posed by climate change mitigation and adaptation. The chapter will describe how and where innovations take place and discuss the market and system failures that deter private sector investments in research and development. Innovation is the outcome of a long complex process involving a system of actors ranging from firms and end users to governments, universities and research institutes. Innovation is also the product of contextual factors such as national laws and regulations, trade regimes, industry standards, intellectual property rights policies, infrastructure, natural environments and geography, all of which bring about different incentives and opportunities. Cultural knowledge can also play an important role in technological change, and must be considered as part of the broader innovation system. The successful development and commercialization of new climate-wise technologies must leverage each and every facet of the innovation system and in particular the private sector.

Technology diffusion is a long, costly, and risky process

7.4 The chapter will assess current global adoption rates of climate-wise technologies. It will then describe how the diffusion of climate-wise technologies is associated with a number of market failures which hinder the effective deployment of promising new technologies—but also how adoption of a technology by one user creates positive externalities by reducing imperfect information and uncertainty barriers. Historical evidence shows that even when a novel clean technology is beneficial to society, it can take a surprisingly long period of time before it is adopted. Sometimes, beneficial innovations are never adopted at all and entire economies remain locked into inferior technological paradigms benefiting from increasing returns to adoption. The problem is especially acute in developing countries, where gaps in the national innovation system, such as a weak skill base, an unfavorable investment climate or information management and dissemination issues, further deepen barriers to technology adoption. Theoretical and empirical evidence suggest that even regulation and price-adjusting mechanisms which reflect climate change externalities are insufficient to overcome barriers to technology diffusion, let alone to innovation.

A mix of policies, customized to the national context, will be required

7.5 The chapter will present policy options for promoting climate-wise innovation and technology adoption, with a specific emphasis on the need to tailor them to the national economic, technological, environmental and policy context. While governments have traditionally supported climate-wise research, development, demonstration, and deployment exclusively through supply-side mechanisms, typically centered on funding public research institutes and universities to generate new technologies, the chapter will recommend key complementary policies to leverage specific sources and channels of

technologies and knowledge flows within the national innovation system.[10] Particular attention will be placed on creating incentives for private sector technology investments and transfer. The chapter will propose strategies to create synergies between innovation and technology policies, and the climate change policies presented in previous chapters of the WDR.

Research, development, demonstration, and deployment targets cannot be achieved without unprecedented international cooperation

7.6 To be effective, efforts to develop new climate-wise technologies will need to involve coordination of research policies and programs as well as knowledge flows across borders. International cooperation can also accelerate technological change if shared technical standards are leveraged to focus efforts and create economies of scale. Massive collaborative efforts and flows of technology through technology-oriented agreements will be necessary to encourage innovation and technology absorption in developing countries. But developing countries, where opportunities for leapfrogging abound, can also be expected to play a key role in pushing forward the technological frontier. While the vast majority of climate-wise research, development, demonstration, and deployment takes place in higher income countries, developing countries will soon account for a majority of greenhouse gas emissions and remain the most vulnerable to the negative effects of climate change.

Chapter 8 Transforming policies and institutions for climate-wise decisions

8.1 This chapter will discuss the institutional, political, and cultural challenges facing national and local government responses to climate change. Building on case studies from a diverse range of countries and sectors, the chapter will delve into the political economy aspects of mitigation and adaptation actions with a view to clarifying the conditions for effective decision making. This will lead to an assessment of how different parts of national and local strategies can be designed, communicated and effectively implemented.

8.2 The likely messages are:

- *Global goals will only be met through effective local action.* Governments will face national and local challenges in meeting their international commitments, while ensuring that climate action remains compatible with equitable development. Given the multi-agent and collective action nature of the climate problem, governments will need to set incentives for local governments, households, communities and particularly the private sector, through pricing, taxation, regulation, and long-term planning.

[10] These will include, for example, financial instruments for both supply and demand of commercial innovation, technological infrastructure and extension programs, skills and brain gain programs, network building programs, and policies governing procurement, standards, information and communication technology, trade, and intellectual property rights.

- *Important dimensions of the climate and development agenda are political and institutional in nature, and must not be overlooked.* These dimensions include facilitating behavior change and garnering public support for controversial and costly policies; designing equitable fiscal and pricing reforms and influencing public opinion about their value; enhancing multi-agency coordination within government; establishing bipartisan decision making frameworks; and building institutions for long-term planning.

- *A robust and sustainable policy agenda for climate change and development is possible.* Some of the priorities of climate policies should include seeking complementary goals, realizing co-benefits, and taking short term actions for long-term goals. It will also require pricing the unpriced, paying attention to processes not only product, and finally, enhancing the management of information.

Global problem, local action

8.3 The global climate change challenge is articulated according to the local context. Despite the global nature of the problem and the need for multi-country engagement, action at national and sub-national level will be key. This is true for adaptation, whose content is mostly national and local, but also mitigation, where countries will face local constraints to abide to their global commitments. Although there is no single recipe or blueprint for achieving low-carbon, climate-resilient societies, governments will face a number of common institutional and political challenges.

8.4 Government 'steering' will go hand in hand with a renewed emphasis on government 'intervention' (links to WDR 1997 and WDR 2002). As at global level, local and national adaptation and mitigation involve collective action challenges. The chapter will explore how governments can support the private sector's contribution in technology innovation and investments through both incentives and regulation, facilitate community-level action, and establish the optimal decentralization of adaptation and mitigation decisionmaking. But the analysis will also posit that in addition to their enabling function, governments will be expected to ensure that targets and goals are achieved, which will likely require a renewed emphasis on regulation, taxation and long term planning, resulting in a new blend of green interventionism.

Politics and institutions matter as much as finance and technology

8.5 As with other environmental and development challenges, the quality of social and governance institutions will be key to effectively attract, deploy and use additional finance and new technology for both mitigation and adaptation. The chapter will build on the broad literature on the institutional determinants of environmental and developmental performance, to assess the social and governance dimensions of effective climate decision making and action. This will be supplemented by case studies highlighting the relevance of similar institutional arrangements across countries and sectors (e.g., water rights in MENA and US Southwest; property rights for avoided deforestation and CCS; long-term decisionmaking frameworks for achieving both mitigation and adaptation

goals; inter-governmental coordination in cutting emissions and managing adaptation funding, etc.)

8.6 Creating the conditions for national and local action requires paying attention to the politics of climate change actions. The chapter will apply different approaches (network, interest group, public choice, and regime theory) to explore the role of different drivers of change and resistance, including coalitions, voter distributions, and veto players. The analysis will additionally focus on effective ways to communicate adaptation and mitigation needs to communities and publics to build political support; the challenges in removing the social and psychological barriers constraining behavior and life-style changes, such as public perceptions of generalized free-riding and climate risk. Particular emphasis will be given to the political and institutional dynamics leading to socially regressive mitigation and adaptation policies in both developed and developing countries.

Establishing an institutionally and politically sustainable policy agenda

8.7 A number of non-market interventions are needed if what some are calling the greatest market failure of all time is to be solved. For example, it is necessary to create (commitment) mechanisms to avoid delaying decisions, policies and actions toward goals with long gestation periods (long-term institution building, research, biodiversity protection, discouraging building in risk zones, etc.) (links with WDR 2003). It is also critical to "*cost the uncosted*": in order to decide whether to bear the costs of a certain intervention, policy makers need to factor in the costs of assets that are normally neglected (coral reefs; forests; NPV of investments given to adaptation concerns, etc.); this also involves assessing the political implications of putting a price on carbon.

8.8 Another policy-making strategy is to *seek overlapping goals and benefits*. Not all climate-wise development policies are necessarily climate specific, and a range of actions can be taken to overcome the perceived trade-off between economic development and climate action. The challenge is to design policy frameworks that clearly frame climate action in terms of broader, overlapping and temporally closer goals and benefits (public health, energy efficiency and security, pollution abatement, disaster risk reduction), and prevent near-term choices that are inconsistent with long-term interests. Strong property rights are fundamental to both mitigation and adaptation issues in various sectors, including forestry, agriculture and urban planning. Social policies such as those aiming at encouraging gender inclusion and civic density have a demonstrated positive role on environmental performance. Green fiscal policies and laws can be designed in such a way so as to play a strong equity and progressive role. And the greening of government, besides providing immediate benefits in terms of emissions reductions particularly in public sector dominated economies, can play an important communicative and exemplary function.

8.9 The long-term nature of the climate change problem implies solutions that require *processes rather than products*. Instead of "once and for all" decisions, governments will need policies that themselves adapt to changing conditions and that combine different instruments into balanced packages. Development of "adaptive policymaking" will

require policymakers to treat policies as ongoing experimental and learning processes, based on targets and milestones, strong performance-based monitoring and evaluation systems and enabling frameworks for interactive engagement with stakeholders and communities. Donors can play a role here in helping countries shape the structure of incentives to encourage action on the ground and decide which types of projects and programs to finance.

8.10 Finally, effective decision making under uncertainty will require enhancing the management of information. Solid information management will be key in disaster risk reduction and in setting up reliable insurance mechanisms. Additionally, it can help people and businesses adapt spontaneously based on their own perceptions of risks and directions of change. Increasing information capacity will not only require the development of new metrics and performance instruments, but also effective systems of information collection, analysis and feedback across different levels of government and across the spectrum of vulnerabilities and impacts. Finally, intra-community communication channels can complement and raise the impact of social safety nets.

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Annex I The beginnings of a bibliography: key climate change publications and reports, existing and under way

The heightened visibility of the climate change debate in the past few years has produced an extensive literature on the economics of climate change, policy responses, international dimensions of climate change, and sectoral and regional topics, in addition to the continued work in the natural sciences. Rather than an exhaustive bibliography, this short review sketches out the broad categories of literature that will inform the WDR, and highlights the major reports that serve as the WDR's point of departure. Papers that are narrower in focus, particularly academic research, policy analyses, and sector- and region-specific studies, though not listed here, will also form a core part of the complete bibliography.

The classics

The IPCC's Fourth Assessment report and recent technical papers (IPCC 2007a-d; Bates et al. 2008) establish the current scientific consensus on physical mechanisms, impacts and adaptation, and technical options for climate change mitigation.

The Millenium Ecosystem Assessment report (2005) was produced through a process similar to the IPCC and remains the classic reference with respect to biodiversity and ecosystem issues.

Sir Nicolas Stern's 2006 Report on the *Economics of Climate Change* is the most influential study in the field of cost-benefit analysis of action on climate change. The key elements are reviewed by Heal (2008), who carefully compares the driving factors in a handful of economic analyses to illustrate that contrary to the approach used by Nordhaus (2007), a broad range of plausible assumptions about discount rates (Stern 2006), catastrophic risk (Weitzman 2007), and ecosystem services (Sterner and Persson 2007), is consistent with a strong case for dramatic action to mitigate and prepare for climate change. Important work on economic impact assessments and global mitigation policy design includes the studies of Mendelsohn et al. (2000), Tol and Yohe (2007), and McKibbin and Wilcoxen (2002).

The sisters

Many UN and other agencies have produced important reports on particular aspects of climate change: the FAO on climate change and food prices (2008); the IEA on energy options (2007); the IMF on mitigation in fast-growing countries (2008); the OECD's Environmental Outlook (2008); UNEP's framework for analyzing growth and energy (Halsnæs and Garg 2006); UNDP's Human Development Report, which is uniquely focused on the development part of the climate change story (2007); UNSEG on science and policy (2007); the WHO on health implications of ecosystem degradation and climate change (2005, 2008). The World Bank's 2008 Global Monitoring Report also included a discussion of environment and sustainable development.

The disasters

The growing literatures on the economic impacts of natural disasters, disaster risk reduction, and environment and conflict complement the climate change impact assessments (particularly around extremes), vulnerability analysis, and adaptation policy projects. Examples include UNDP (2004); German Advisory Council on Climate Change (2008); World Bank (2005); Benson and Clay (2005).

The road to Copenhagen

The writing and dissemination of this report coincide with the lead up to the December 2009 UNFCCC negotiations in Copenhagen, and the WDR must be aware of both the political sensitivities and the opportunities for success. The political context, including legal debates, national priorities, and plausible roadmaps to a successful deal are covered in a handful of recent reports (Stern 2008; Blair et al. 2008).

More is under way

The UNFCCC secretariat is preparing background reports on finance and technology for the Poznań (December 2008) meetings of the Conference of Parties. Lord Stern and the British Office of Climate Change are producing a policy paper and a high level conference that is aimed to helping the negotiation process. The Stockholm based Commission on Climate Change and Development is preparing a report on the Human Dimensions of Climate Change, to be released in March 2009. The Asian Developmennt Bank is producing a report on climate change with a focus on agriculture, infrastructure, water, and energy. The IEA is preparing new reports on renewable energy technologies and outlook to be published in September 2008.

A number of reports and analyses of relevance to climate change are also under way within the World Bank. An ambitious two-year initiative, funded by DfID and the Dutch Government is analyzing the "*Economics of Adaptation*." Another which is being prepared in parallel to the WDR is on the "*Economics of Disaster Risk Reduction.*" The Social Development Unit is undertaking work on the social dimensions of climate change. The Regional Vice-Presidencies are working on or have completed their own flagships. Finally, five country-specific studies are being conducted in association with the relevant governments on low-carbon growth strategies.

More generally the WDR team is coordinating closely with a number of ongoing initiatives elsewhere in the Bank in order to avoid duplication, share knowledge, and ensure that the Bank's climate change research and policy portfolio, as a whole, addresses the topics of greatest concern to our clients. The WDR has greatly benefited from the Bank's Strategic Framework on *Development and Climate Change*, a consensus document now in place after an extensive consultation process, which defines the institutional contextual framework for the analyses of the WDR.