How can decision-makers in developing countries incorporate uncertainty about future climate risks into existing planning and policy-making processes?

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How can decision-makers in developing countries incorporate uncertainty about future climate risks into existing planning and policy-making processes?[1]

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Abstract

Climate change is increasingly altering the pattern of climate-related risks. Developing countries, and in particular least developed countries, will be among the most severely impacted by climate change. The challenge for planners and policy-makers today is that it is impossible to predict with certainty the future conditions to which adaptation is needed. This paper sets out simple, practical principles that aim to reduce the impact of uncertainty on decision-making. It also draws out three interconnected messages for decision-makers. Firstly, for adaptation to be effective, comprehensive and implemented at the appropriate scale, it is crucial to integrate adaptation planning within existing priorities, planning processes and policymaking. Secondly, adaptation strengthens the case for pushing 'faster and harder' on development priorities. Finally, through building flexibility into adaptation strategies from the outset, climate resilience even under deep uncertainty should be no more challenging than other areas of policy. A central principle in managing uncertainties is to focus on promoting good development and long-term adaptive capacity while avoiding inflexible decisions that could lock-in future climate risk in the long term.

1. Introduction

Policymakers around the world make decisions every day that impact the exposure of societies to climate hazards and their ability to cope with events when they occur. Some have direct impacts, for example, investments in new flood defences or early warning systems. Others, such as developmental policies and governance, including agricultural policy, health, education and institutional structures, have a more indirect impact.

Climate change is increasingly altering the pattern of climate-related risks that society has become used to. These changes will affect lives and livelihoods in many ways, through for example, changing agricultural conditions and water supplies, sea level rise

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and increasing intensity of extreme weather events (Parry *et al.* 2007). There is substantial uncertainty, however, about local impacts. Some regions could see reductions in one type of hazard but increases in another, while others could become more exposed to hazards and risks rarely before experienced.

For some, these risks seem remote. But if climate change is not considered upfront in existing planning and policy-making processes today, decision-makers risk locking-in future impacts that may prove irreversible or much more costly and difficult to rectify than is necessary (Box 1). For example, existing infrastructure and social policies (such as urban planning) may not be suitable in a warmer climate and in some cases this could lead to greater damages from climate-related risks and slower economic growth and development. Policy and spending decisions are made every day that could increase future vulnerability to climate change or miss opportunities to reduce future impacts. There are many other advantages in acting ahead of time; for example, adaptation can also bring immediate benefits, such as building economic resilience and reducing damages from extreme weather today.

Box 1: Uncertainty and the Risk of Maladaptation

The consequence of not considering the uncertainty in future climate risks is to expose a society to *maladaptation*, where decisions are made (for instance, on the basis of incorrect forecasts[4]) that are found to be unsuitable for the climate that occurs. Maladaptation can mean expensive, wasted investments and unnecessary, possibly irreversible, harm to people and ecosystems e.g. the expense of prematurely replacing infrastructure that was built in a way that is unsuitable for the climate over its lifetime. This is an example of *under-adaptation*, where there is either no action or adjustments do not go far enough to cope with the climatic changes that occur. Other forms of maladaptation are: *over-adaptation*, where adjustments are made that prove to be unnecessary e.g. a sea defence built to withstand 4m of sea level rise that does not occur; and *incorrect adaptation*, where adjustments are made, but are later found to be either not adaptive or counter-adaptive.

In general, societies are quite good at adapting to the climate (Burton, 2009), but adaptation in a changing climate brings new challenges. The speed and extent of the changes limit the ability to adapt reactively, so societies need to plan ahead. It also means that decision-makers can no longer rely on history as a guide to future levels of risk (Hallegatte, 2008) or even current risk levels.[5] Together this means that in a changing climate, adaptation must shift from a backward-looking paradigm to one based upon assessing and forecasting current and future levels of risk. The challenge is that it is impossible to predict with certainty the future conditions to which adaptation is needed (Annex 1).

[4] Other potential causes of maladaptation are poor planning and implementation.
[5] There are many technical difficulties in estimating the scale of man-made contributions to climatic changes observed today, particularly for 'rarer' extreme events, such as heavy rainfall and droughts. For example, in many regions, the time series of meteorological and hydrological observations is too short, or the information too scarce, to detect statistically robust trends in extreme events (e.g. Ward and Ranger, 2010).

This does not mean that adaptation can not take place or should be delayed in anticipation of better information. Such information is not a prerequisite for adaptation. This paper focuses on approaches to overcoming the apparent barrier to adaptation created by the uncertainty in future climate-related risks, with a focus on their application to developing countries. Such approaches can have particular benefits for developing countries, where uncertainties in information for adaptation (climate and otherwise) tend to be greatest, as a result of scarcer meteorological, hydrological and socioeconomic data (UNISDR, 2009). This paper outlines a set of simple, practical principles to give some guidance on how decision-makers in developing countries can incorporate uncertainty into existing policymaking and planning processes today.

2. Managing uncertain climate risks in developing countries

Developing countries, and in particular least developed countries, will be among the most severely impacted by climate change. This is partly due to geography; these countries tend to be located in regions of the world with harsher climates or that are coastal low-lying areas, so even small changes could have severe impacts.

But, in many cases, the main reason that developing countries are likely to be more severely impacted is their greater social and economic vulnerability to climate (both current and future). This greater vulnerability has two components, both of which are associated with development. Firstly, developing countries tend to have a higher economic exposure to climate. For example, in developing countries, a greater proportion of the population have livelihoods that depend on climate-sensitive economic production, such as rain-fed agriculture. Hence, the share of climate-sensitive gross domestic product (GDP) is higher (Stern, 2007). The livelihoods of poorer communities are also more heavily affected by the degradation of natural resources (such as forests, coral reefs and ecosystem services) as a result of climate and other factors, including deforestation and over-intensive agriculture.

Secondly, developing countries tend to have a lower capacity to adapt to climate, because of, for instance, weaker institutions and risk governance, fewer resources to invest in risk management (including early warning systems and protective infrastructure), a lack of social protection and an overexploited environment (World Bank, 2010a; UNISDR, 2009).

This greater social and economic vulnerability to climate can be seen today in annual disaster loss figures. For example, while the incidence of natural catastrophes is similar in developed and developing countries, 90 per cent of deaths from these events occur in the developing world (Hoeppe and Gurenko, 2006). According to estimates from the global reinsurance company Munich Re, since 1980 weather-related catastrophes in low and lower middle income countries[6] have caused almost 850,000 fatalities and led to damages amounting to US$40 billion. Such disasters have long-term impacts on economic development and poverty reduction through drawing resources away from development and putting individuals, firms and governments under stress (World Bank, 2010).

These data illustrate that developing countries have a wide 'adaptation deficit' to manage today's climate variability (Burton, 2009), but they also highlight that adaptation can have immediate and long-term benefits through reducing climate risks and supporting economic development and poverty reduction.

However, adaptation may also present greater challenges in developing countries, due in part to the lower adaptive capacity (e.g. Parry *et al*. 2007, World Bank, 2010). Developing countries may come up against greater barriers to adaptation, such as a lack of information, capacity and relevant skills, resource constraints, more pressing near-term needs, lack of political will and weaker institutions.[7]

The principles laid out in this paper aim to help to overcome two of these barriers. The first is the lack of information, capacity and skills. A lack of information leads to additional uncertainties about climate risks and about the best approach to responding. This is compounded by constraints on capacity, skills and resources for detailed decision analyses. Sections 3 and 4 lay out some simple, practical principles that aim to reduce the impact of uncertainty on decision-making, which can be applied either at a high (resource-light) level, or at a more detailed level, depending on needs and resources.

The second challenge comes from the more pressing near-term needs that call on the limited funds available in developing countries, for example, to support access to energy, improved health care and poverty reduction. Section 4, demonstrates that adaptation and development priorities can be aligned and that, in fact, climate change strengthens the case for pushing 'faster and harder' on development policies and investments. In the words of Nicholas Stern (2009), adaptation should not be seen as an additional policy agenda to deliver, but as "development in a harsher climate".

In developing countries there is an even more urgent need to incorporate long-term thinking about climate risks into existing planning decisions and policy processes as significant funds are being invested every day in long-term infrastructure developments in sectors such as energy, water and transport. For example, in 2008, 35% of core International Development Association (IDA) funds, or almost US$5 billion per year,

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[6] Source: the Munich Re NatCatSERVICE database. Note that these numbers are likely to be an underestimate as many losses in developing countries, particularly to communities and individuals, would are not formally recorded.

[7] Note that these barriers to adaptation are not unique to developing countries, but tend to be felt more strongly in them, particularly the least developed countries, than in developed countries,.

were spent on agriculture, flood protection and water supply projects alone[8] and it has previously been suggested that roughly 40% of all World Bank lending (in total, over $20 billion per year) for projects in developing countries could contain climate-sensitive components[9]. This, of course, constitutes only a fraction of all current long-term investment in developing countries.

In summary, the risks from climate change are greater in developing countries than in developed countries, but the potential benefits from good adaptation can also be greater.

3. The process of adaptation planning

This paper aims to demonstrate that in many cases, adapting under uncertainty need not be more complex than any other area of policy. Specifically, developing a robust plan to cope with climate change need not necessarily be about applying complex and resource-intensive decision analyses on a project-by-project basis. More important is to integrate a set of principles for long-term, robust climate resilience into existing planning, policies and programmes.

Before focusing on the principles for managing uncertainty, Box 2 lays out some simple guidelines for good practice to mainstream adaptation into day-to-day policy, drawn from the Pilot Programme for Climate Resilience (PPCR). For adaptation to be effective, comprehensive and implemented at the appropriate scale, it is crucial to integrate adaptation planning within existing priorities, planning processes and policy-making. This paper aims to demonstrate that this integration process can also be beneficial for managing uncertainties in decision-making.

Box 2: Good practice case studies from the PPCR in developing countries

The Pilot Programme for Climate Resilience (PPCR) is a targeted fund designed to provide financial support for countries to transform to a climate resilient development path, consistent with poverty reduction and sustainable development goals, through adhering to several principles of good policy design and implementation, as well as through knowledge sharing. The PPCR is one program of the Climate Investment Funds (CIF), a collaborative effort among the Multilateral Development Banks and countries to bridge the financing and learning gap between now and a post-2012 global climate change agreement[10].

[8] http://siteresources.worldbank.org/IDA/Resources/IDA-Climate_Change.pdf
[9] Estimate by Ian Noble, World Bank (e.g. presentation to the 11th Conference of Parties in 2005 http://www.iges.or.jp/en/news/cop11/adap/noble.pdf)
[10] For more information, see: http://www.climateinvestmentfunds.org/cif/keydocuments/PPCR

The objectives and guidance of the PPCR (CIF, 2009) imply a series of good principles relevant to managing uncertainty as well as integrating adaptation within existing priorities. These are summarised below alongside examples of their application in the pilot programmes[11]:

- **Coordination at national level:** Adaptation will tend to be implemented at the local level, but the state plays an important role in integrating adaptation into poverty reduction and sustainable development goals across sectors and policy areas, for example by identifying gaps, exploiting synergies (e.g. co-benefits with conservation) and resolving trade-offs with other policy goals. The state also plays an important role in incentivising adaptive behavioural change at a local scale and in providing a delivery channel through public services, such as meteorological services, emergency services, education and research and development.

  Case study: The PPCR in Zambia is building on national policy processes such as its Sixth National Development Plan (2011-2015) and a National Climate Change Response Strategy.

- **Broad-based and participatory planning:** Country-led adaptation planning has often been undertaken by a single line ministry, usually the Ministry of Environment, rather than by a central ministry leading on planning. Ministries of the environment are very important to the process of developing national adaptation strategies, but the impacts of climate change cut across the remits of most government departments and affect large parts of society. Therefore, it is important that a strategy to build national resilience is developed and implemented by not just one line ministry or NGO, but by a broad range of stakeholders from cross-sectoral government departments, non-government actors, including civil society groups and highly affected communities, and the private sector. No single institution can understand the needs of all groups in society or design and deliver the full range of required adaptation goods and services. A range of stakeholders must be involved in planning and decision-making from the beginning.

  Case study: The PPCR pilot in the Caribbean has engaged representatives from regional development institutions, ministries of planning, finance, land management and environment, academics, donor agencies, think tanks, interest and political groups, and development banks.

- **Programmatic and integrated with existing priorities:** Climate resilience must become part of existing priorities and policy areas, such as poverty reduction, social protection, trade policy, long-term security, disaster risk management, water resource management, agricultural policy, forestry and environmental protection. Developing a programme of action, rather than adopting a piecemeal project-by-project approach, gives the right incentives for scaled-up, comprehensive and cross-cutting climate resilience.

  Case study: The PPCR pilot for Bangladesh includes a comprehensive cross-sectoral investment programme for coastal regions that integrates with existing priorities, including: promoting climate resilient agriculture and food security; investing in the improvement of coastal embankments and afforestation; and improving water supply, sanitation, and infrastructure.

- **Looking beyond the short term:** To avoid maladaptation (Box 1) at a national scale, it is important to consider how climate impacts reinforce or alter development priorities for

[11] Note that the case studies described in Box 2 are based on work in progress by PPCR pilot countries and incorporate announcements as of 4 March 2011 – they are subject to revision as countries' plans are added, changed or clarified.

the short, medium and long term.

Case study: The PPCR pilot in Tajikistan is investing in building stronger institutional capacity and awareness of climate change amongst civil society, the media and highly vulnerable groups such as women and children, with benefits that will outlast the tenure of any process.

- **Implement a continuous process, not a one-off:** Adaptation is a continuous process, involving planning, implementation, reviewing performance and monitoring climatic changes.

  Case study: A shared goal of all of the PPCRs is to initiate a transformational shift towards a climate-resilient development path through building capacity, information and initial investments to design and implement a long-term strategic programme for resilience rather than one-off projects.

- **Learning the lessons:** A strategy must build on existing processes and should incorporate learning from other countries and regions as far as possible to avoid expending unnecessary resources.

  Case study: A principle of the PPCR process is to integrate planning with existing programmes. For example, countries such as Samoa and Cambodia are designing programmatic adaptation strategies to update and implement the NAPA.

The principles outlined in Box 2 lay the groundwork for a robust approach to managing uncertainties by encouraging a decision-maker to begin by considering where adaptation fits within existing national, regional and local priorities, recognising relevant opportunities and trade-offs, and clearly identifying and agreeing what needs to be achieved by adaptation. Several experts have argued that this type of 'policy-first' approach is also the right approach for designing strategies that are robust against uncertainty (Carter *et al*. 2007; Wilby and Dessai 2009; Dessai *et al*. 2005; Ranger *et al.* 2010). They argue that starting with the adaptation problem itself, rather than the climate models, not only facilitates better integration with existing priorities, but also reduces the data and resources needed for adaptation planning. By enabling the planner to first identify those issues that need the most attention and where information is lacking, resources can be allocated most efficiently. This avoids wasting resources on generating information that is not pertinent to making decisions.

Box 5 outlines an example of agricultural policy in Mozambique where most adaptation options are found to either give benefits both today and in the future climate, or can be adjusted reactively (e.g. crop-planting times and varieties can be changed seasonally depending on the climate). In this case, detailed long-term climate projections have little relevance to decision-making and resources might be focused elsewhere instead on overcoming other challenges in adaptation.

Of course, some information about future climate projections will usually be required, but in many cases this need not be a detailed and resource-intensive exercise. For example, given the large uncertainties inherent in climate risk projections (Appendix 1), there will always be greater returns from understanding, roughly, the range of what might happen over time, rather than from relying on detailed 'best guess' projections (which tend to be more resource-intensive to obtain). In many cases, applying resources to gather other information inputs (or investing in improved information) could prove to be of greater value in making a good decision, for example, building a better understanding of the 'stress points' (or tipping points) in current water systems or crops[12] and working out how to cope with these (Carter *et al*. 2007; Wilby and Dessai 2009; Dessai *et al*. 2005; Ranger *et al.* 2010).

These arguments lead to a set of simple first steps in planning adaptation that complement the principles outlined in Box 2, and aim to help the decision-maker understand adaptation needs as well as identify gaps in knowledge and critical uncertainties. These steps are based on Ranger *et al*. (2010) and Willows and Connell (2003). They should initially be taken at a high (resource-light) level and then refined later where necessary in order to clarify adaptation plans. Some examples of key issues for decision-makers are:

1. **Understand current vulnerability:** Identify where national/regional priorities and programmes (e.g. poverty reduction goals), as well as local lives and livelihoods (in particular, in relation to vulnerable groups, ecosystems and natural resources), are susceptible to the impacts of weather and climate today. How does climate affect these areas? What factors are driving vulnerability? How would the climate need to change in the future to impact these areas?
2. **Scope (initially, at a high level) future risks related to climate change and the uncertainties involved:** Roughly, what does the available evidence indicate about the range of climatic changes that might be expected in the future and the level of uncertainty around these? Given what is known about vulnerability today, what types of impacts might be expected in the future across the range of uncertainty? How will this affect current priorities and programmes? Could global and regional impacts begin to affect citizens and policy in new ways (e.g. migration pressures)? What are the potential 'hot spots' of risk, how will these evolve over time, and what are the driving factors behind them? Where could further information be helpful?
3. **Evaluate adaptation objectives and constraints in the context of broader priorities:** What would be the objectives of adaptation in the areas identified? What would successful adaptation look like? Are there any constraints that need to be considered or overcome?
4. **Identify potential adaptation options:** What types of adaptation options would be appropriate given these objectives and constraints? Would these

[12] Information on 'tipping points' can often be of greatest value in adaptation planning, but can also be a source of uncertainty. This can be critically important when dealing with potentially irreversible impacts, such as the loss of coral reefs. It can be managed using the same approaches that are used for other sources of uncertainty, for example, in connection with climate projections or vulnerability.

options have benefits today or only under particular future conditions? Do they need to be implemented ahead of time, or are they responsive? How flexible are they to climate, e.g. are they long-lived and difficult to change once implemented, or are they short-lived or adjustable? Who would implement them and who would be affected? Do they have any co-benefits and trade-offs?

The desired outcome of this initial process is to identify where there are clear adaptation steps that can be implemented today and what options might be needed in the future, as well as enabling a decision-maker to identify where more detailed analysis or data collection is necessary to make a decision. Gaining this understanding first can avoid a waste of resources on detailed analyses that are not necessary. The next step might be to refine decisions by collecting more information or conducting more detailed analyses where it has been found to be necessary. This might include, for example, collecting more information on current vulnerability to weather, refining a list of adaptation options or conducting detailed cost-benefit analyses of different options.

Ranger *et al*. (2010) suggest that, in general, only in a few cases will a resource-intensive analytical process be justified. These tend to be decisions involving investments or policies that are expensive and/or high stakes, such as sector-level planning (for example, investing in new agricultural programs) or large-scale public infrastructure projects (like regional water management systems), where there are complex trade-offs to consider and where the choice is particularly sensitive to assumptions (about future climate or other factors). Typically, future climate risk will be an important factor in decision-making under the following conditions: firstly, where there is high sensitivity to climate (e.g. ecosystems or vulnerable communities); secondly, for long-lived investments and policies, such as public infrastructure; and thirdly, where there are long lead times so that there is a need to make an early start, such as reducing social vulnerabilities or investing in technological research.

Section 4 discusses a set of principles for evaluating adaptation options and developing adaptation strategies that are robust to changes and uncertainties in future risk.

4. Managing uncertainty: focus on principles, not projections

Decision science has developed a range of methods to aid decision-making under deep uncertainty which are now being applied to real adaptation problems[13], including water supply management in California (Groves *et al*. 2008) and storm surge management in London (Haigh and Fisher 2010).

These applications have tended to be both data- and resource-intensive and so could appear beyond the reach of those in least developed countries who are working under information and budgetary constraints. However, the methods each boil down to a

[13] For an accessible review of these methods in the context of adaptation, we refer the reader to Section III.C of Ranger *et al.* (2010) and the accompanying technical appendices (Ranger *et al.* 2010b).

number of simple principles that can be applied at a higher level to incorporate uncertainty into current planning and policy-making processes. These principles are outlined here, along with examples and case studies illustrating their application to developing countries.

i. ***Firstly, consider long-term climate risks within existing planning and policy-making processes such that, where possible, policy-makers avoid making decisions today in ways that could actually lock-in impacts, increasing future vulnerability to climate or leading to expensive retrofits later on.***

The types of decisions that are most likely to increase future vulnerability or lead to maladaptation tend to be those involving sector-level planning (e.g. water, fisheries and agriculture), regulation and, most commonly, long-lived infrastructure. For example, an urban planning policy that promotes the building of new homes in areas exposed to flooding may put people, property and infrastructure at risk. This is illustrated by the informal settlements in Mumbai, where many thousands of people live along the banks of the Mithi River, which floods regularly – more than 1000 people were killed in the Mumbai floods of 2005 (Ranger *et al.* 2011). Every year, an extra 25 million people move into similar urban informal settlements within some of the world's largest cities in developing countries (UNISDR 2009). In many cases, there are pressing reasons for building in higher-risk areas, but in the long run they could prove expensive. Usually, it will be less expensive overall to make decisions climate-resilient from the start by integrating adaptation into existing planning and policy-making processes.

ii. ***Secondly, move faster and harder on core development objectives.***

Well-designed development policies are a 'no-regrets' form of adaptation, giving both immediate and long-term benefits in any future climate. Development, or the lack thereof, is a critical aspect of vulnerability to climate change (Fankhauser and Burton 2010; McGray *et al*. 2007; Klein and Persson 2008). It has been demonstrated that measures like economic diversification, poverty alleviation, improved health care, education and sanitation have multiple and immediate benefits, enhancing human development, building economic resilience and significantly reducing vulnerability to climate change. Effective planning systems and public institutions, access to markets and credit, and sustainable natural resource management can also build capacity to respond effectively to climate change, as well as other challenges (Vivid Economics 2010). Fundamentally, a healthy, well-educated population with access to social protection can better cope with the shocks and stresses that will be associated with both current climate and long-term climate change (World Bank 2010a). Box 3 provides an example of such benefits in Bangladesh.

Box 3: Development and risk reduction in Bangladesh

Bangladesh provides an example of the benefits of core development strategies for enhancing economic resilience to climate risks and reducing vulnerability. Before 1998, flooding and tropical storms led to significant damages and fatalities in Bangladesh and had a direct negative effect on GDP growth. More recently, Bangladesh has experienced reduced impacts from natural hazards as a result of a combination of core development and disaster risk management strategies, including economic diversification (reduced dependence on agriculture and greater focus on the export of clothing), better access to micro-finance in poorer communities, and improved state-level response and financial management following a disaster. For example, in 1998 Bangladesh experienced the worst flooding since the 1940s, but unlike in previous flooding events, as a result of disaster risk reduction and preparedness activities, the 1998 event did not have a significant impact on economic output; for example, the level of agricultural production was still double the level that was forecast prior to the disaster and remained high.

The benefits of these strategies is further illustrated by comparing the effects of Cyclone Sidr on Bangladesh (November 2007) and Cyclone Nargis on Myanmar (May 2008). The two cyclones were very similar in size and intensity, but they had very different impacts on these two countries because of the disaster risk management strategies that were in place. In Bangladesh, around 4,200 people were killed, while in Myanmar it is estimated that more than 138,000 people were killed[14]. The countries have a similar human development index and GDP. Analyses suggest that the differences in impacts were mainly due to the disaster preparedness and risk reduction investments made in Bangladesh. In Bangladesh, a 48-hour early warning system and evacuation procedures meant that 3 million people left prior to the event, with 1.5 million going to cyclone shelters. In Myanmar the government received 72 hours notice, but there was no early warning system for communities and so no evacuations took place. In Bangladesh, many households were protected from the surge by embankments and the Sundarbans, an extensive mangrove system, provided a natural buffer against the severe effects of storm surges. In Myanmar there were no such defences and most of the mangrove systems had been destroyed. This example starkly illustrates the significant benefits already gained through adaptation.

Source: AUSAID (2008) and Vivid Economics (2010), based on Benson and Clay (2004)

However, development strategies may need to change to facilitate adaptation and avoid locking countries into a vulnerable development path (Fankhauser and Burton 2010; Vivid Economics 2010). These changes include[15]:

a. greater focus on management of natural resources (including water supplies, air and water quality, and forests) and ecosystems, with emphasis on promoting long-term sustainability and resilience;
b. more awareness of near-term and long-term risks in policy-making, including recognising potential maladaptations; for example, recognising that policies to incentivise businesses to maximise productivity and growth can expose poor people to unacceptable risks (e.g. over-intensive agriculture);
c. greater use of state and community actions to ensure climate-resilient growth and development throughout society and the economy (e.g. training and regulation of building standards and land use) and to provide public goods with co-benefits for adaptation (Cimato and Mullan 2010), such as emergency

[14] Data source: EM-DAT: The OFDA/CRED International Disaster Database, www.emdat.be - Université catholique de Louvain - Brussels - Belgium
[15] Based on the list of actions outlined in Fankhauser and Burton (2010) and Vivid Economics (2010).

services, distributing climate and risk information to promote adaptation by individuals, protective infrastructure, social safety nets to support poor people, and research into new medicines and agricultural technologies; and

d. improved awareness and management of other trends that could increase vulnerability to climate risks (Ranger *et al*. 2010). For example, better management of land use to retain natural ecosystem services (e.g. using green spaces to maintain natural drainage in cities, and enhancing soil fertility through sustainable agricultural practices) and incentivising water efficiency to reduce the impacts of increasing demand.

iii. Thirdly, focus on additional measures that directly reduce vulnerability to current climate-related risks and limit near-term, irreversible harm to people and ecosystems.

Climate change provides an additional argument in favour of implementing comprehensive disaster risk management strategies, like those laid out in the Hyogo Framework (UNISDR 2005). Policies and investments that directly reduce current climate risks from, for example, droughts and flooding, provide immediate support for economic growth and development, protect people and assets, and represent an important part of long-term adaptation to climate change. These include appropriate 'hard' adaptations, such as emergency services, early warning systems, flood walls, drainage systems and water supply infrastructure, and 'softer' adaptation measures, such as awareness-raising through training and information, regulation, insurance and evacuation planning.

A further priority is the implementation of policies and measures that reduce significant and/or irreversible impacts to people and ecosystems with high vulnerability to weather and climate change in the near term (i.e. the next 5 to 10 years or so). For example, many ecosystems, such as coral reefs, have a high sensitivity to even small changes in climate and are susceptible to irreversible effects, including extinction. Damages to ecosystems will have negative effects on biodiversity, local livelihoods (fisheries, agriculture and tourism) and ecosystem services. Planning and policy-making processes should aim to identify such risks and, where possible and desirable, take measures to avoid negative impacts[16].

A package of 'no-' and 'low-regrets' measures like those outlined above, including development policies, early warning systems and improved emergencies services, can go a long way toward fulfilling national adaptation objectives. 'No-regrets' does not

[16] A potential issue here is that it can sometimes be difficult to foresee impacts and pinpoint key 'tipping points', particularly for ecosystems. The appropriate response in such circumstances will depend upon the preferences of the decision-maker. For example, a decision-maker may decide that some potential impacts demand a precautionary approach. In other cases, a decision-maker may opt to 'wait, observe and learn' while taking 'low-regrets' measures that reduce the vulnerability and build the resilience of the system (e.g. by reducing other pressures on ecosystems, such as intensive agriculture). An example of this type of decision analysis is provided by Lempert and Collins (2006).

necessarily mean zero cost or that there will be no trade-offs with other priorities (e.g. whether to build in floodplains); here, it means that the measures will have benefits today and under any future climate. Thus, plans are made robust to climate uncertainties and then the desirability of their costs, benefits and trade-offs can be weighed up in the same way as any other policy choice.

In some cases, an adaptation problem can not be completely solved using 'no-regrets' measures. The design of some adaptation strategies will depend more on what is assumed today about future climate. These include, for example, long-lived infrastructure and long-term projects, like agricultural research. However, these types of investments and strategies can often have significant benefits in terms of future risk reduction. For example, a study on adaptation for flooding in Guyana (Box 4) found that a set of 'no-regrets' measures, including early warning systems and better maintenance of drainage systems, have net benefits of around US$72million today, whereas more climate-dependent measures, such as upgrading the drainage systems (where their design depends on the future climate), could have benefits of over US$500million under a high climate change scenario (Climate Works Foundation 2009).

Other examples of potentially 'higher-regrets' decisions are as follows. Is it worth investing in research to engineer crops that are better at coping with severe drought conditions? Should we begin relocating people away from potential high-risk coastal floodplains? Should we invest in irrigation systems in drought-prone areas? Traditionally, each of these decisions would require forecasting future climate. However, the nature of the uncertainties around climate change means it is difficult to make such forecasts. The following principles aim to help robust decision-making in these cases:

Box 4: Robustness of flood risk management in Guyana and Mozambique

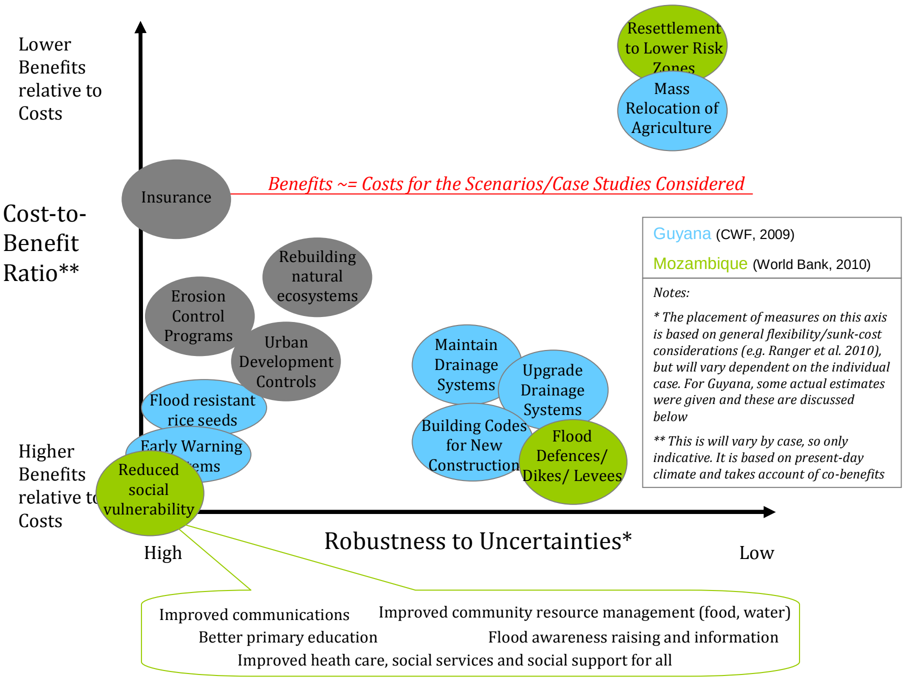
The relationship between the economic cost-benefit ratio and the robustness of measures to climate change uncertainties can be illustrated using findings from two recent studies on adaptation to flood risk in Guyana and Mozambique (Climate Works Foundation 2009; World Bank 2010b). Both of these countries have experienced damages from flooding in recent years and climate models suggest that climate change could alter flood risk in the future. The Guyana study focused more on 'hard adaptation options', such as drainage systems, whereas the Mozambique study also explored 'soft adaptation options' such as reducing social vulnerability.

The following figure shows the relative costs and benefits of flood management options for Guyana (blue bubbles) and Mozambique (green bubbles) on the vertical axis, based on the findings of the two studies[17]. The grey bubbles are purely illustrative, drawn from other case studies by the Climate Works Foundation (2009) and the World Bank (2010b)[18]. Those measures

[17] The exact placement of options on the y-axis of the diagram is generalised as in reality the options are case dependent (e.g. the benefit of building codes is greater where flood risk is higher). The figure also includes additional co-benefits not included in the studies; specifically, the benefit to cost ratio is shown to be higher for "rebuilding natural ecosystems" than is suggested by Climate Works Foundation (2009).

[18] For example, the Climate Works Foundation (2009) also analysed adaptation to flooding for a UK city.

at the bottom of the figure have the highest benefits relative to costs, and those at the top have the lowest benefits relative to costs. For example, the Climate Works Foundation (2009) found that for a case study in Guyana, improved building codes would have greater damage reduction benefits relative to costs than upgrading the drainage system.



The cost-to-benefit ratio is only one factor that it important in decision-making. Another important factor is the robustness of adaptation measures to uncertainties about future climate[19]. This is shown on the horizontal axis of the figure[20]. Robustness measures the degree to which the benefits of the adaptation measure vary with assumptions about future climate[21]; it can be thought of as the risk of maladaptation. For example, on the left-hand side of the figure are 'no-regrets' options (i.e. high robustness), such as early warning systems and improved education, and health care, which have strong benefits in any climate. On the right-hand side are the 'higher-regret' options (i.e. low robustness), such as drainage systems and flood defences,

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[19] Other factors may also be important, such as equity, environmental impact, protection of people or the avoidance of some risk threshold.
[20] The positioning of the measures on the x-axis is illustrative and is case-dependent. The approximate positions for the Guyana study are based on the findings of the Climate Works Foundation (2009). The positions for the Mozambique study are based on considerations of the nature of the measure (e.g. whether it aims to reduce general vulnerability or the impact of a specific hazard), the average lifetime of the measure, the irreversibility of the investment, whether the measure is anticipatory or reactive, and simple assumptions about how the benefits would vary with climate (e.g. drawing on the findings of Ranger *et al.* 2010b).
[21] For example, Groves *et al.* (2008) measures robustness using a metric known as 'regret', which quantifies the difference in performance of a strategy compared with the best performing strategy across a range of possible future climate scenarios.
[22] The Climate Works Foundation (2009) provided information on economic benefits versus costs for a set of adaptation measures under two climate change scenarios (an increase in rainfall in one and a small decrease in rainfall in the other). By comparing the cost-benefit ratio of different measures for the two scenarios it is possible to draw some implications for the robustness of those measures. The one measure that was found not to be robust was mass relocation of agriculture. The study found that this measure would only become economically viable if rainfall were to increase substantially, far more than is predicted by current climate models. Note that a comprehensive planning process would usually consider a broader range of climate scenarios.

where the choice of measure (and the resulting benefits) is more dependent on assumptions today about the future climate.

It is important to note that the robustness and cost-benefit ratios of measures vary on a case-by-case basis and the locations of the bubbles in the figure above are illustrative. For example, the Guyana study found that while the benefits of measures do depend on the climate scenario[22], for most measures, the benefits outweighed the costs under all scenarios, suggesting that these measures are 'no-regrets' for Guyana. Similarly, while for the Mozambique case study resettlement to lower risk zones was found not to be cost-beneficial under a central climate scenario, in other (higher risk) locations this may not be the case.

Note that 'high-regrets' options are not always substitutable with 'low-regrets' options (e.g. better primary education is not a direct substitute for an improved drainage system); in many cases, different measures are complementary. Importantly, 'high-regrets' options can be made 'lower-regrets' by building in flexibility (Section 4.iv).

iv. ***Where dealing with expensive, long-term projects, such as public infrastructure, seek 'low-regrets' ways to build in flexibility to cope with the uncertainties at the start (both in future climate and other factors, such as critical thresholds). There are three general ways to do this, which might be used together or independently*** (based on Fankhauser *et al*. 1999):

a. ***Design measures and policies today to cope with a wider range of possible climate conditions.*** For example, encourage and help farmers to grow drought-resistant crops that are suitable for a much harsher climate. This means potentially 'over-adapting' to climate change, but it can be desirable where the extra expenses are low. It is not likely to be desirable where the costs are high, for example building sea walls today that would only be needed if sea levels rise by several metres.

b. ***Designing measures and policies today that can be easily and inexpensively adjusted later to cope with future climate conditions.*** For example, build a sea wall or reservoir today with larger foundations so that it can be adjusted later if necessary, rather than replaced. Again, this is a good approach where the extra expense is low (i.e. it is 'low-regrets') or the chance of needing to make the adjustment is high. For example, the Thames Barrier that protects London from flooding was designed so that it could be over-rotated (i.e. heightened) to cope with greater sea level rise.

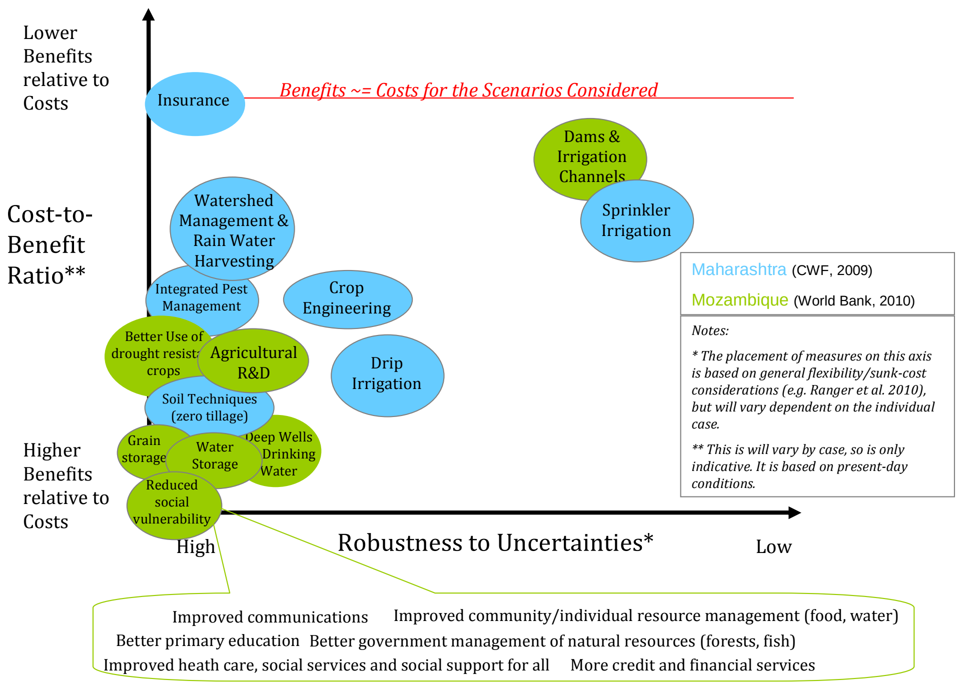
c. ***Design strategies that use a package of adaptation measures that are sequenced over time to reduce current climate risks while maintaining flexibility to cope with future risks***. For example, a decision-maker could focus on 'no-regrets' options in the near term (e.g. in the case described in Box 5, using drought-resistant crops to better cope with current climate conditions as well as promoting economic diversification, primary education and access to credit and markets) while also putting in place flexible measures to help support long-term adaptation (such as investments in agricultural research and development). More 'inflexible' and expensive investments, such as large-scale sprinkler systems for irrigation, that have a lower cost-benefit ratio today and more uncertain long-term benefits, might be delayed for a few years until better information is available (with regular review).

v. ***In all cases, put in place processes and systems to monitor and regularly review progress and risks, and take action accordingly.***

As time progresses, more will be learned about the success of different adaptation measures, key thresholds and the trajectory of future climate change. Regular reviews of progress and adjustments to adaptation plans will be essential in ensuring a robust response to climate change. Monitoring of key indicators, such as climate, ecosystems and social vulnerabilities, is important to detect early warning signals that adaptation plans may need to be adjusted. Adaptation processes should be flexible enough to make adjustments as more is learned, objectives evolve and new information is gathered.

Box 5: Agricultural adaptation in Maharashtra and Mozambique

The figure below applies the framework of Box 4 to illustrate the robustness of different options to manage drought risk to agriculture in Mozambique (green bubbles, based on World Bank 2010b) and Maharashtra (blue bubbles, based on the Climate Works Foundation 2009). As in Box 4, the exact location of bubbles is illustrative and is case-dependent.



In this case study, many more 'no-' or 'low-regrets' options are available to manage climate risks (i.e. the left-hand side of the figure); in other words, the majority of the options available will have benefits under any scenario, including reduced social vulnerability, wells for drinking water and soil management techniques. One reason for this contrast with flood management (Box 4) is that the majority of measures identified by the Climate Works Foundation (2009) and World Bank (2010b) do not involve long-lived, expensive infrastructure. Also, some of the measures are more *reactive* to climate; such as the use of drought-resistant crops, which can be adjusted annually to cope with climatic changes. The only options that could have a higher risk of maladaptation are those involving irrigation, which are relatively expensive and have benefits that depend on future rainfall. Drip irrigation is more robust than sprinkler irrigation as it is more water-efficient.

Occasionally adaptation planners may come across a case where it is not possible to rely on only 'no-regrets' measures or to make decisions that are flexible to cope with uncertainty. Where it involves dealing with high-stakes investments or decisions, this type of case[23] will usually justify a more detailed appraisal of options (e.g. Groves *et al.* 2008; Ranger *et al.* 2010). In such cases, options might be more clearly differentiated by consideration of all the co-benefits and trade-offs of actions (e.g. environmental impacts, energy needs and job creation).

In the majority of cases, through applying these types of principles, adaptation strategies can be made robust against uncertainties, and adaptation planning will be no more challenging than any other area of policy-making. This is particularly the case in developing countries as multiple benefits can be gained through moving faster and harder on core development priorities and reducing current climate risks, and there are more 'low-regrets' opportunities which can incorporate flexibility into long-term planning and projects.[24]

5. Conclusions

This paper has described a set of simple, practical principles that aim to reduce the impact of uncertainty on decision-making. These principles can be applied either at a high (resource-light) level, or in more detail, depending on needs and resources. It has shown that through building flexibility into adaptation strategies from the outset, climate resilience even under deep uncertainty should be no more challenging than other areas of policy. In summary, a key principle for managing uncertainties in

[23] This type of case could be identified by going through the steps outlined in Section 3. An example of such a case could be if there were an urgent need to upgrade water infrastructure, and all 'no-regrets' options, such as improved water efficiency, had been exploited, so that the only choice was between two expensive and irreversible options that were suitable under different climate scenarios (e.g. building a new reservoir or investing in a desalinisation plant). Thus, key determinants of such a case would be: (i) high sensitivity of a decision across the range of projected changes in climate; (ii) high sunk-costs (i.e. an irreversible and expensive investment); (iii) urgency of the decision (or high costs of delay); and (iv) lack of suitable 'no-regrets' options to reduce near-term risk and form a 'stop-gap'.

[24] Conversely, in developed countries, decision-makers are often making tough choices between costly upgrades and the replacement of aging and inadequate infrastructure.

adaptation in developing countries is to focus on promoting good development and long-term adaptive capacity while avoiding inflexible decisions that could lock-in future climate risk in the long term.

This paper has also shown that a 'policy-first' process to adaptation planning, focusing on adaptation needs, rather than detailed climate projections, is also important for managing uncertainties, as well as integrating adaptation within existing planning and policy-making processes and helping to focus limited resources where they are most needed.

An important conclusion of this paper, emphasised by many previous authors, is that adaptation and development are not opposing priorities that must be weighed up against each other by countries with limited resources. Adaptation and development priorities are aligned. Climate change strengthens the case for pushing 'faster and harder' on development priorities and investments, with a greater awareness of long-term risks.

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Technical Appendices:

1. The nature of uncertainties in climate risk projections

To form a set of principles, it is important to understand the nature of the uncertainty in future climate risk and its consequences for adaptation planning.

Uncertainty itself is not necessarily a problem as decisions are made under uncertainty every day. For example, engineers routinely make decisions about the design of infrastructure to cope with local weather conditions, which by their nature are chaotic and uncertain. However, in the case of future climate risks, the uncertainties are such that science is not yet able to give robust estimates of the likelihood (i.e. probabilities) of different scenarios. Over-reliance on such projections can lead to maladaptation (Hall, 2007).

Why are projections of future climate risks so uncertain? Producing a forecast of future climate risk requires forecasting many different elements along a chain from man-made emissions to climate, then the impacts of climatic changes and their risks to society. Each step of the chain incorporates more uncertainty, leading to an explosion of uncertainty in the end risk estimate (Jones 2000). Crucially, the sources and types of uncertainty differ at each step and few (if any) can be quantified (Stainforth *et al*. 2007a, b; Dessai *et al.* 2009). Recently, authors have begun to describe this situation as *ambiguity* or *deep uncertainty*. The level of uncertainty also increases over time and at the local scales needed for adaptation.

Continued research to better constrain projections is important. However, it is highly unlikely that further research will significantly reduce uncertainties in future climate risk on the timescales that many adaptation decisions need to be made. This raises challenges for traditional decision-making approaches. The ambiguity in projections means that a decision-maker cannot know how decisions should be made today to maximise benefits against costs. It is not possible to predict exactly how high a sea wall should be to most cost-beneficially manage storm surge risk over the next 50 years. Adaptation requires a new approach to managing uncertainty.