How Can Developing Country Decision Makers Incorporate Uncertainty about Climate Risks into Existing Planning and Policymaking Processes?

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INTRODUCTION

Planning and policymaking processes in many developing (and developed) countries have historically ignored climatic uncertainty. There are several reasons for this. For example, climate was taken into account in planning but assumed to be stationary and thus well defined by past climate records and its statistics; or climate was assumed to be negligible when compared with other more important issues (e.g., poverty alleviation or economic development). Under a changing climate it is becoming increasingly clear that existing planning processes may require adjustments in order to incorporate uncertainty about future climate (Dessai and van der Sluijs 2007; NRC 2009).

THEORETICAL PRINCIPLES

One of the key principles of robust approaches to decision making is the identification of strategies that are immune to uncertainty. In the broad arena of planning and policymaking, uncertainties arise from a myriad of sources, of which climate is just one, sometimes important, sometimes not. Thus, uncertainties in planning could arise from: decisions being taken in another country, internal political instability, increased inequity and numerous other factors. **Immunity to uncertainty** is a key principle for decision making in a changing climate. This principle requires decisions that are taken to be insensitive to uncertainties. Which uncertainties and tools are relevant are dictated by the decision-making context. Understanding the decision-making context is absolutely critical to figuring out whether uncertainty is an issue or not. For example, the temporal scale of the planning horizon could be an important determinant of whether uncertainty is relevant or not. Planning for the next six months should be less dominated by uncertainties than planning for the next 25 years. In general, as planning horizons increase so does the magnitude of uncertainties. However, even short planning horizons can suffer from substantial uncertainties when the existing knowledge base is low and data are lacking.

A key, and often difficult, step in decision making is **acknowledging uncertainty**. Often it is easier for decision-makers to ignore or hide uncertainties in order to convince a minister, boss or constituents of a particular plan of action. If uncertainties are significant this approach can potentially lead to bad outcomes in the future (such as maladaptation; cf. Barnett and O'Neill 2010). By acknowledging uncertainty, decision-makers are taking the first step in improving existing planning processes.

Decision making is context specific, such as adapting water resources management to a changing climate. How the problem is framed (**problem framing**) will often dictate what sorts of tools of analysis are used and how uncertainty is treated. For example, a predict-then-act framing leads to different approaches of uncertainty management than an assess-risk-of-policy framing (Lempert, Nakicenovic et al. 2004). A predict-then-act framing focuses heavily on characterising and reducing (the latter is often mentioned but rarely achieved in a long term planning context) the uncertainty of climate and climate impact projections before decisions can be taken. The assess-risk-of-policy framing starts with the decisions and works its way backwards to assess how much uncertainty a given portfolio of decisions is capable of handling in order to reach its objectives (Dessai, Hulme et al. 2009).

Assuming an assess-risk-of-policy framing is chosen for a particular context, the next step is the examination of the **decision space**. The decision space can include a number of options, strategies, plans or policies that could be implemented by one or many actors. The identification of options and strategies should be conducted with stakeholders and these should be encouraged to think out of the box (e.g., consider options that may not be available today, but could be feasible in a couple of years). The idea is to collate as large as possible portfolio of options in order to map out a comprehensive decision space.

The next step involves coming up with **agreed criteria** for the things we value (or at least attempt to) amongst those making and being impacted by climate-related decisions. For example, in a broad sense this could be termed sustainability, but it could be useful to further break down criteria into economic, social, environmental, etc. A key criterion should be immunity of strategies to uncertainties.

At this stage it is necessary to **characterise uncertainties** for the problem at hand. There is no one size fits all approach for all decision contexts. Decision makers, who have worked in a particular context for a number of years, should be able to identify some of the main uncertainties that affect a particular activity. Experts are often relied upon to characterise a number of drivers and the uncertainties associated with them. This is where climate science and climate impact experts (including those with local and traditional knowledge) may be sought to provide an assessment of current and future climate impact risk (with uncertainty). Once all drivers of an activity have been characterised (including its uncertainties) it is now possible to assess the performance of strategies against the criteria we value. The complexity of the methods and tools to undertake this analysis varies according to the available data, knowledge base and technical capacity (see: Wilby et al., 2009).

In a data/knowledge/resource poor context we may simply compare strategies qualitatively using narratives of future states of the world to explore the uncertainties in key drivers. In data/knowledge/resource rich contexts it may be possible to run quantitative models linking drivers of change (and their uncertainties) with an activity (e.g., water availability) to assess the merit of different strategies (as in Lopez et al. 2009). Advanced techniques, such as robust decision-making (Lempert and Groves 2010), allow the visualisation of strategy performance against multiple uncertainties and multiple criteria. This allows the decision maker to evaluate different trade-offs (e.g., maximising immunity to uncertainty versus maximising expected utility). A number of decision analytic techniques exist to tackle the above: cost-benefit analysis, cost-effectiveness analysis, multi-criteria analysis, probabilistic risk assessment, etc.

Evidence from the literature shows that flexible and adaptive strategies are more likely to be robust to uncertainty as opposed to static strategies (Hallegatte 2009; Lempert and Groves 2010). In order to build this sort of flexibility it is necessary to constantly monitor the activity in question and revisit the action plan regularly, particularly as new knowledge becomes available. This will allow the plan to be augmented or relaxed depending on the pace, direction and significance of evolving climate risks.

Traditionally, decision makers have relied on experts to provide scenarios of future states of the world to inform their planning processes. The approach described above acknowledges uncertainty and thus places greater onus on decision makers to be explicit about the level of uncertainty that he/she is prepared to take (or the amount of money spent or damages accepted, which will relate to a particular level of uncertainty). There is evidence in the literature that experts are often overconfident (Cooke 1991); we therefore suggest expanding the ranges of uncertainties provided by experts to reduce the chance of surprises. By definition, surprises or "wild cards" are extremely hard to envisage, but they can be incorporated into robust planning. Analysts and decision makers could co-produce a number of surprise scenarios to be included in the analysis. These scenarios are characterised as surprise scenarios because they could be inconsistent with mainstream scenarios; they try to explore non-linearities, abrupt change or just challenge widely accepted assumptions of gradual change. Because the future is uncertain, it is impossible to prepare for everything, but the steps above should increase the resilience of systems to climate change and other uncertainties.

ADAPTATION OPTIONS AND PORTFOLIOS

According to the IPCC Fourth Assessment Report (2007) there is a low level of consensus (i.e., high uncertainty) amongst climate models even about the sign of the change in seasonal rainfall over large parts of Africa, Asia and South America. When uncertainty in such an important variable is combined with the high vulnerability of populations, it makes sense to identify development strategies that perform well (though not necessarily optimally) over a wide range of conditions faced now and potentially in the future. Ideally "no regret" strategies should yield benefits regardless of climate change. In practice, there are opportunity costs, trade-offs, or externalities associated with adaptation actions so it is better to refer to such interventions as "low regret." Such measures should address present development priorities as well as keeping open or maximising options for adaptation in the future. For example, protecting water sources from contamination is a sound strategy under any climate context. Likewise, long-term monitoring of environmental quality is necessary for estimating the sustainable resource and for benchmarking changing conditions or the outcome of management decisions. Other examples of low regret water management measures are listed in Table 1. All make sense regardless of the very uncertain outlook for climatic and non-climatic drivers of water availability.

Scientific and climate risk information
• Centralise meteorological data collection, quality control and dissemination
• Support meteorological data rescue and digitization
• Monitor baseline and environmental change (indicators) at reference sites
• Improve surface and groundwater models leading to more reliable resource estimates
• Improve understanding of regional climate controls and land surface feedbacks
• Develop real-time, seasonal and decadal forecasting capability
• Improve the dissemination and uptake of forecasts for emergency management
• Survey at high resolutions to identify zones most vulnerable to coastal and fluvial flooding
Water management practices
• Strengthen water governance and methods of allocation
• Undertake source protection from pollution and salinization
• Increase agricultural (and urban) drainage water re-use
• Manage artificial aquifer recharge
• Undertake asset management and maintenance (leakage control, urban drainage systems)
• Improve water efficiency (domestic, agricultural, industrial sectors)
• Develop faster growing and/or more drought resistant crop cultivars
• Employ traditional water harvesting and retention techniques (such as terracing)
• Test contingency plans and improve post disaster management

Table 1. Examples of "low regret" adaptation measures for water management

The above measures provide a necessary starting point but may not be sufficient. Furthermore, the options available to urban and rural populations are not the same. There may also be trade-offs between urban and rural water needs, and those of the environment (to maintain biodiversity). Therefore, it is more plausible to consider low regret measures (Table 1) within larger portfolios of measures (Table 2), recognizing that there will be dependencies between some options. For example, enforced metering and increased water tariffs may not happen in the absence of wider water policy, governance reforms and compliance monitoring. The design of the portfolio must also consider the sequencing of measures since they are unlikely to be invoked simultaneously. It is inconceivable that desalination plants would be installed ahead of measures that cost less and offer the prospect of real water savings (Miller, *pers. comm.*).

A FRAMEWORK FOR ROBUST ADAPTATION

The framework proposed here builds on the theoretical principles introduced earlier for application in developing countries. The framework prioritises adaptation measures that are low-regret or reversible, incorporate safety margins, and employ 'soft' solutions (see below) are flexible and mindful of actions being taken by others to either mitigate or adapt to climate change (Hallegatte 2009). Assuming that the most significant risks posed by climate (and non-climatic) hazards have been identified, the first step is to construct an inventory of all such adaptation options (labelled A, B, C in

Urban	Rural	Biodiversity
Increase urban water re-use Protect groundwater sources from pollution Conserve water (leakage control) Improve water use efficiency (appliances) Increase public water tariffs Install desalination plants Import agricultural goods with high embedded water Enforce metering, billing and revenue collection	Increase agricultural water re-use Protect groundwater sources from pollution Conserve water (piped irrigation systems) Promote artificial aquifer recharge Improve water use efficiency (irrigation scheduling) Develop drought resistant cultivars Adjust cropping calendar Change crop mix Employ traditional rainwater harvesting and retention Expand rain-fed source areas Increase irrigation water tariffs Install solar desalination plants	Conserve wetlands and floodplains Maintain terraces for soil and water conservation Conserve local landraces and their wild relatives

Table 2. Portfolios of options for improving water security (semi-arid regions)

Figure 1). This set could include hard engineering solutions and retrofit to existing infrastructure, as well as soft solutions involving re-allocation of resources, behaviour change, institutional and/or sectoral reform/restructuring, awareness raising, or risk spreading via financial instruments (Wilby et al., 2009). Through screening and appraisal (via for example multi criteria analysis) it should be possible to identify a sub-set of preferred adaptation measures (labelled B, H, S, and W in Figure 1). Ideally, these would reduce vulnerability under the present climate regime, while being socially acceptable, technically, and economically feasible given the prevailing regulatory environment. If the lifetime of the scheme is a few years or less, then it may be sufficient to test the measures using recent climatology. If the lifetime of the measure spans multiple decades (as in the case of a new reservoir or irrigation system) then it is necessary to evaluate performance across a range of scenarios.

This is the point at which regional climate scenarios might inform the options appraisal by establishing plausible upper and lower bounds to climate change sensitivity testing. Where impacts models are available, options' performance can be quantitatively analysed under different combinations of precipitation, temperature, sea level, etc. change as required. Other, non-climatic drivers (such as land-use change) might also be introduced to the sensitivity testing at this stage. For many practical purposes, detailed numerical modelling may not be feasible (because of time, cost, technical constraints, etc.) or even necessary if the option delivers benefits regardless of the climate outlook (e.g., water saving measures). If no regional climate projections are available it may be necessary to revert to narratives about climate change from global climate models (such as "warmer," "delayed melt," "more extremes").

Even qualitative descriptions of climate variability or the direction of change can help planners embrace uncertainty by looking for more resilient options that meet agreed standards. Measures that pass the sensitivity test and/or comply with accepted principles are then deemed to be robust to climate change (labelled B and W in Figure 1). For example, using a narrative of "greater water scarcity" a programme of de-silting traditional water tanks was supported in preference to the construction of a new $4billion dam in Andhra Pradesh, India (Pittock 2008).

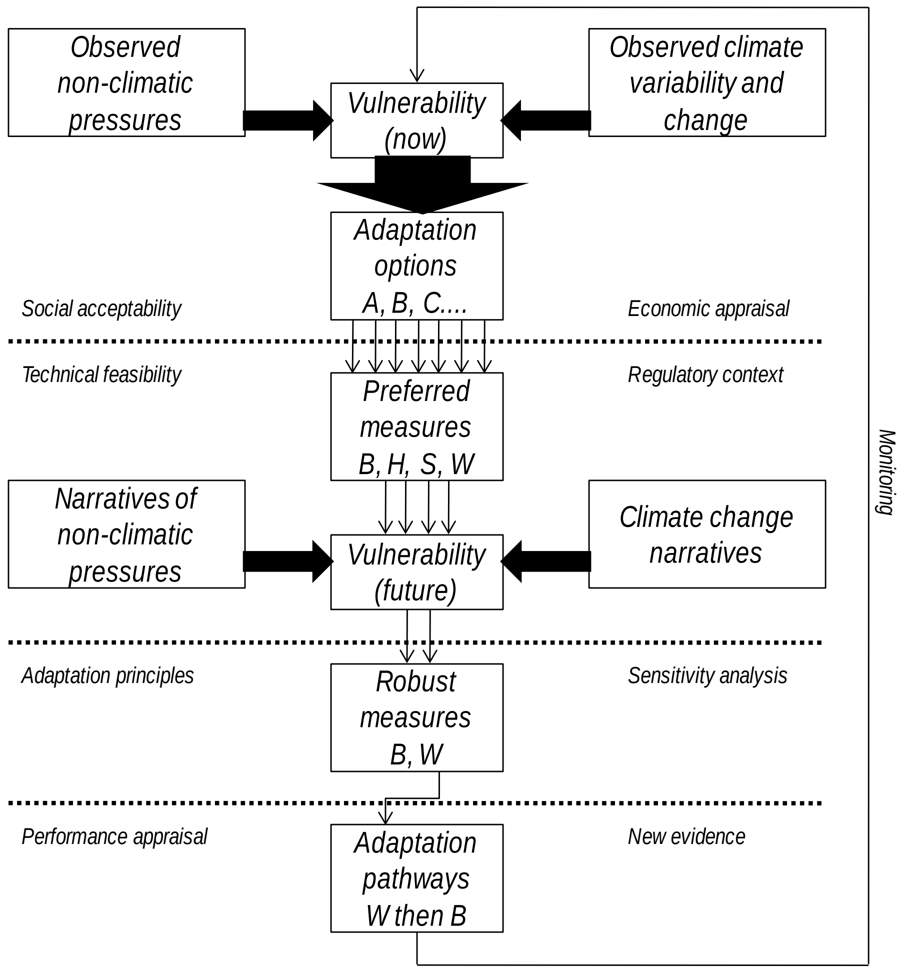

Figure 1. Conceptual framework for the assessment of robust adaptation options (Wilby and Dessai 2010)

Given the long-term commitment to global mean temperature increases and sea level rise – even if emissions are dramatically reduced in the short term – adaptation is an open-ended process rather than a one-off solution (Royal Commission on

Environmental Pollution, 2010). Adaptive management of climate risks involves careful monitoring of the environment and systematic appraisal of the performance of measures. The resulting adaptation pathway will be shaped by the evolving scientific evidence and societal attitudes to risk. As noted above, there is also path dependency, given that present and future adaptation options depend on decisions that have been taken before. Lock-in, whether due to physical structures, policies, or technologies, limits the scope for further adaptation.

CASE STUDY: WATER MANAGEMENT IN YEMEN

Even without climate change, Yemen is already facing a water crisis. When the photograph in Figure 2 was taken, Yemen's population was estimated to be 2.5 million (compared with the UN estimate of 21 million in 2005). At the same time the country's average annual precipitation was ~10% higher than today. Thanks to the introduction of diesel pumps and subsidies in the 1970s, groundwater is being mined at an alarming rate—depleted at more than four times the estimated recharge rate in major aquifers, such as the Sana'a basin. With renewable annual water resources of only 195 m^3/per capita (in 2005), Yemen is highly vulnerable to any reduction in rainfall-recharge to aquifers. Furthermore, the precipitation regime is characterized by short-lived, intense storms that generate flash floods, interspersed by long dry periods of severe drought. For example, on 24-25 October 2008, flash flooding claimed the lives of 180 people, destroyed 2000 houses and displaced more than 10,000 in the Hadramaut and Maharah provinces.

Figure 2. Spate irrigation systems in Hadramaut, Yemen in the late 1920s. Photograph: Bull

Some projections foresee increased water scarcity for the Middle East and Arabian Peninsula as a consequence of rising demand and falling supply. But the outlook is far from clear-cut in terms of projected changes in rainfall. According to the IPCC Fourth Assessment Report (2007) there is no consensus amongst the 21 climate models about the sign of the projected changes in winter, summer or annual rainfall for Yemen. Local changes in annual rainfall span –34% to +56% depending on the choice of climate model (Figure 3).

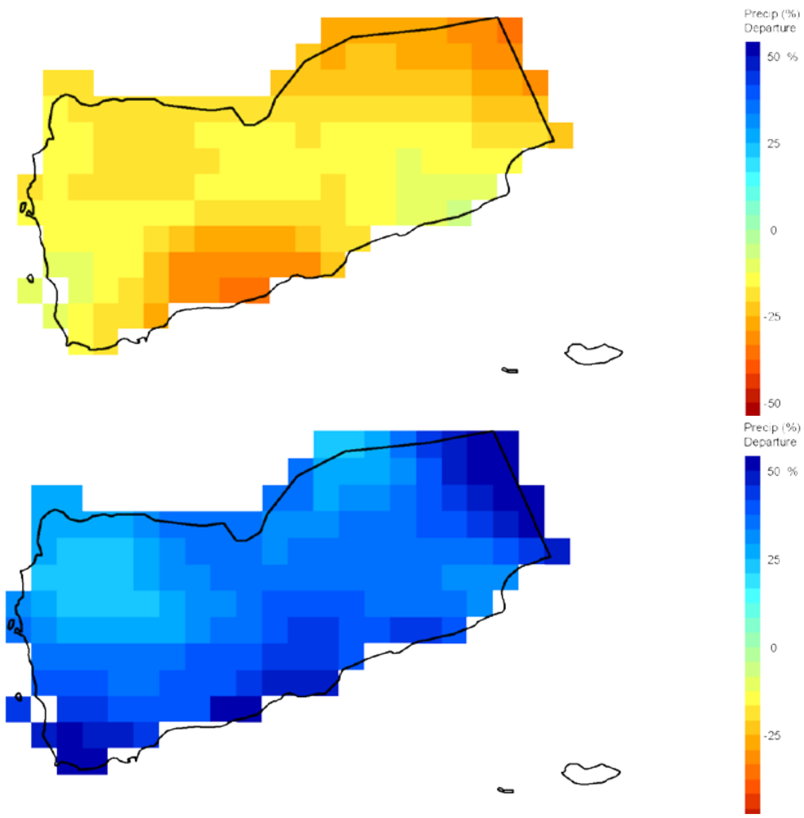

Figure 3. IPCC Fourth Assessment Report ensemble range for annual precipitation change across Yemen by the 2050s under SRES A2 emissions (top: driest model; bottom: wettest model). Data source: Climate Wizard

Although the anthropogenic climate change signal is detectable and growing, it is expected to remain a relatively small component (when compared with large natural climate variability of dry-lands) for the next few decades. Hence, the sustainability of the Millennium Development Goals (such as access to safe drinking water by 2015) could be undermined by climate change in the long term, but risk exposure will be most immediate where human and environmental systems are already marginal (such as some rain-fed agricultural regions, or coastal zones susceptible to tidal surges). In these cases, even modest changes in the mean climate or to extremes could exceed coping ranges.

Given the large uncertainty in regional precipitation scenarios coupled with the already high vulnerability of populations, it makes sense to identify strategies that perform well (though not necessarily optimally) over a wide range of conditions faced now and potentially in the future, i.e., “low regret” measures (Table 1). All would yield benefits regardless of the very uncertain outlook for climatic and non-climatic drivers of water availability in Yemen.

Sentiments of “low regret” and “robustness” are echoed by the climate strategies being developed by Yemen and other countries in the region (Table 3). For example, Djibouti’s National Adaptation Programme for Action (NAPA) seeks to reduce the adverse effects of climate change through the improvement of adaptation capacities of vulnerable populations while at the same time contributing directly to the implementation of a poverty reduction strategy. Furthermore, the NAPA favours the development of synergies with current environmental initiatives and the establishment of links with projects that support national development priorities. One immediate priority is to survey land use and improve information on natural hazards to identify most vulnerable populations. This is regarded as a step towards raising awareness across society and government, and for introducing effective, long-term risk reduction mechanisms such as land use zoning or building design. In the meantime, improved hazard forecasting and dissemination, emergency response and post disaster management, could all help to build adaptive capacity irrespective of climate uncertainty.

This short paper has demonstrated, both in theory and practice, how decision makers can incorporate climate change uncertainty into long-term planning. Robust adaptation to climate change requires decision makers to acknowledge and embrace uncertainty. The adaptation context will play an important role in the selection of tools and methods of analysis. The identification of low regret measures will enable decision makers to enhance the resilience of socio-ecological systems to climate and other uncertainties.

1. Develop and implement Integrated Coastal Zone Management programmes
2. Water conservation through reuse of treated waste water and grey water from mosques, and irrigation saving techniques.
3. Develop and implement an awareness raising programme on adaptation to the potential impacts of climate change.
4. Establish and maintain database for climate change and adaptation
5. Planting and re-planting of mangroves and palms for adaptation to projected sea level rise
6. Develop and implement programs to improve Yemen's preparedness to cope with extreme weather events
7. Rainwater harvesting through various techniques including traditional methods
8. Rehabilitation and maintenance of mountainous terraces.
9. Promotion of research on drought resistant and heat- and salinity- tolerant crops.
10. Design and implement sustainable land management strategies to combat desertification and land degradation
11. Sustainable management of fisheries resources.
12. Incorporation of climate change and adaptation to school education

Table 3. Ranked set of priority adaptation options listed in Yemen's draft NAPA[1]

[1] http://unfccc.int/resource/docs/napa/yem01.pdf

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