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Managing Climate Risks in Developing Countries with Robust Decision Making

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Imagine a civil engineering team in a developing country tasked with designing a new road in a flood prone area. This team must determine its location, height, grade, and other key features. They face many challenges. Changing intensity and frequency of flooding may threaten the long-term viability of the road. Limited resources will likely exist to protect the road against uncertain future threats. The team may lack basic data, not only on future climate, but also on the current patterns of flooding in the region. In addition, rapid economic development may make it difficult to predict accurately the volume of future traffic on the road and the future land use patterns that will surround it.

This situation is not unique. Climate change poses significant and ubiquitous risks to developing countries. Many such nations are growing and building new infrastructure very rapidly, suggesting that today's investment decisions will have long-term consequences. They face pervasive shortages of the data and models generally used to plan for such changes. Moreover, their rapid development creates tremendous uncertainty about future demographics, economic growth, technology, regulations and policies, as well as about the future climate.

How can decision makers plan wisely in this challenging context? Traditional analytic methods seek to predict the future, asking, "*What will the future bring?*" and then help decision makers to choose the best option for that future. By their nature, such approaches face numerous organizational and implementation barriers.

Robust decision making (RDM) is a decision framework that inverts the analytical steps that are typical of traditional analytic methods and seeks to identify choices that are robust over many alternative views of the future. In this way, RDM reframes the question, asking, "*How can we choose actions today that will be consistent with our long-term interests?*" This paper illustrates how RDM can help overcome many of the shortcomings of traditional approaches that make it difficult plan for climate change in developing countries.

Traditional Analytical Approaches Often Fail

We continue following the work of our road design team to understand the challenges that traditional analytical approaches present. Consistent with traditional approaches, the road design team would attempt to assemble credible regional projections for future climate change and use these projections to estimate future flood frequencies. The team would seek this information in order to determine which design best reduces risks from future climate change.

This basic approach assembles projections of an uncertain future (i.e. making predictions) and then uses these projections to determine the best decision (i.e. choosing a course of action). The approach rests on well-developed theoretical foundations and informs a vast body of widely used analytic methods, including risk analysis, cost-benefit analysis, operations research, and many other common planning methods. Such approaches, which we have termed "predict-then-act," prove immensely valuable when uncertainties are well characterized. But when uncertainties are deep – that is, when decision makers do not know or cannot agree on how their actions relate to potential consequences and on the likelihoods of alternative futures – these predict-then-act methods can often prove difficult to implement and can exacerbate barriers to good decision making. Developing countries in particular routinely face such conditions of deep uncertainty when they attempt to include climate change in their plans.

Predict-then-act methods can prove difficult to implement in developing countries because the methods often require extensive data for adequate forecasts. Downscaled regional climate projections with sufficient temporal and spatial resolution may be unavailable. Planners may lack sufficient data and models of local hydrology to make any effective use of such climate data. Sensitivity analyses may fail to provide useful guidance on what information is most important.

Predict-then-act methods can also exacerbate cognitive and organizational barriers to good decision-making. The approach reinforces tendencies towards overconfidence. When data collection is challenging, or when there is difficulty identifying the best decision because uncertainties are too large, there is a natural tendency for decision makers' to downplay the extent of uncertainty in order to make definitive recommendations.[1] This overconfidence often results in decisions that perform poorly when the unexpected comes to pass.

Predict-then-act approaches can also make it more difficult to achieve consensus among parties to a decision with differing interests and differing expectations about the future. Each party understands that the choice of assumptions will often drive the recommendations from the analysis. When little solid information exists to resolve conflicting assumptions, parties will often gravitate towards those assumptions most consistent with the choice they already favor. Predict-then-act analyses offer little to dislodge them from such positions.

Finally, decision makers often possess significant information that can prove useful in distinguishing the desirability of alternative decision options which is not very useful for making predictions. Thus traditional quantitative analysis provides few entry points for this important type of local knowledge.

Robust Decision Making Can Address Organizational and Implementation Barriers

RDM can help developing countries address many of the planning challenges posed by climate

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[1] There exists a large literature on the perils of overconfidence for decision making. For one review see Lempert and Popper (2005).

change adaptation. In its full form, RDM is an iterative, analytic decision support methodology -- sophisticated statistical and software tools embedded in a process of participatory stakeholder engagement. Perhaps even more importantly, RDM also offers a simple heuristic framework for planning and project design that can prove valuable even when it is not necessary or possible to conduct a full analysis.

RDM combines three key elements. First, RDM reverses the order of traditional predict-then-act analyses. RDM begins with a candidate decision (for example, our team's initial road design), and then identifies the future conditions under which that decision is vulnerable (e.g. a sea level rise of 1m coupled with a 6% increase in rainfall may make the road unviable).[2] In this way, RDM characterizes uncertainty in terms of its effect on the decision's ability to achieve its goals. Next, RDM helps identify steps that might be taken to reduce those vulnerabilities, and then illuminates tradeoffs among these steps. In contrast, traditional analyses first characterize the uncertainties, independently of the various choices under consideration.

The structure of the IPCC Assessment Reports is a prominent example of this traditional ordering of steps. Working Group I begins by laying out what is known and uncertain about current and future changes to the climate system. Working Groups II and III then describe impacts and potential policy responses to those changes, respectively. In contrast, RDM begins with potential policies and asks what is known about current and future climate that might suggest this policy would fail to meet its goals. The IPCC may require this traditional ordering of steps because it serves diverse audiences. But reversing the order of the analysis can prove valuable when supporting specific decision makers considering a specific set of options, particularly when combined with RDM's other two key elements.

The second key element is that RDM characterizes uncertainty with multiple views of the future. Traditional approaches certainly consider multiple futures -- for instance cases with more or less climate change. But these approaches regard the multiple cases as having known likelihoods so that they can be summarized with a single set of best-estimate statistics. In contrast, RDM adopts the idea of scenarios as fundamentally different, alternative views of how the future might unfold. It does not assign best-estimate likelihoods, instead treating each simply as one of many plausible futures. Used in this way, multiple futures can help describe imprecision in likelihood estimates and help reduce overconfidence by encouraging decision makers to consider a wide range of possibilities rather than seek a single best estimate. In its full form, an RDM analysis will generate hundreds to many thousands of simulation model runs and, as described below, uses statistical analysis to summarize them with a handful of the most important scenarios for decision-makers to consider. This process can help build consensus

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[2] In many cases, for instance those involved with ecosystem protection, the thresholds at which a system fails may not be known or well understood. Such cases often require, as described below, strategies that evolve over time in response to new information (e.g. adaptive management strategies) so that the RDM analysis emphasizes early warning indicators and the response to such indicators as a means of managing systems with uncertain thresholds. See, for example, Lempert Collins (2007).

among parties to a decision with different expectations about the future by enabling even conflicting views to be included within the analysis.

Finally, RDM seeks robust decisions, not necessarily optimal ones. Robust decisions perform well compared to the alternatives over a wide range of plausible futures, even if they aren’t the best possible approach given any one view of the future. If decision makers agree on and are confident in their probabilistic information, they may prefer optimal decisions. But robust decisions have several advantages. Combined with the scenario concept, they can help promote consensus among groups with different expectations and values because the group can agree on a course of action without first agreeing on expectations about the future. Within an analysis that characterizes vulnerabilities of proposed decisions and considers multiple futures, using the robustness criteria – that is seeking policies that perform reasonably well over a wide range of plausible futures -- can help reduce the tendency to underestimate uncertainties because it encourages decision makers to consider the full range of futures that may challenge a proposed decision. Thus robust decisions tend to be less brittle to surprise. Finally, a robust decision is one that performs well independent of a wide range of futures and thus is sensitive to at most a small set of potential uncertainties. This property helps reduce data requirements for evaluating such decisions, because the analysis will demonstrate that many factors are not important to the choice among alternative options.

One of the most effective means to achieve a robust decision is to explicitly design it to evolve over time in response to new information. Public and private sector organizations’ policies are often adaptive in practice, but traditional approaches make it difficult to make them adaptive by design. In contrast, RDM focuses attention on designing adaptive plans. For instance, many water management agencies in developed countries publish formal planning documents looking out several decades, and they update these plans every few years. Typically such plans do not explicitly note, or make use of, the future updates that will certainly occur. With RDM, however, some agencies have begun to develop explicitly adaptive plans, identifying how knowledge available in a future planning exercise could be used to choose from the options outlined in a current planning exercise. This offers a means for ensuring they can thrive over a wide range of assumptions about future climate change and other factors.

Using RDM does not guarantee that decision makers will find a robust strategy. In some situations decision makers face difficult and irreconcilable tradeoffs. But our practical experience with RDM and evidence from the behavioral sciences from which it is derived suggest that the approach may improve, relative to alternative approaches, decision makers’ ability to identify and reach consensus on strategies that can manage a wide range of uncertainty. An RDM analysis can also help decision makers to more clearly recognize those futures where their plans may not perform well.

These three elements – characterizing uncertainty with multiple views of the future, focusing on those futures that illuminate vulnerabilities of proposed decisions, and seeking decisions with robust performance across these multiple futures – are not unique to RDM. Scenario planning methods employ multiple views of the future. New analytic methods such as InfoGap and robust control theory have emerged to examine robust decisions.[3] Decision makers concerned with climate change commonly undertake vulnerability analyses. But RDM usefully combines all three elements in a way that addresses the cognitive, organizational, and implementation barriers that have often made it difficult to plan for climate change in developing countries.

RDM as a Heuristic Framework for Analysis

While full-form RDM uses sophisticated software and statistical tools and can be data and resource intensive, these three fundamental elements of RDM also offer a heuristic framework for planning and project design. In some situations, this heuristic framework may provide developing countries many of the benefits of a full RDM analysis.

As an example, the team of engineers discussed above could use this framework to reduce the risks to their road from climate change using data and simulation models they already have in hand for developing their existing plans for their road.

First, the engineers would begin with the current design for their road, that is, the design that does not consider any future change in flood frequency or other effects of climate change. The team would also specify the performance objectives their road aimed to achieve.

Second, they would ask the question, "*What future combinations of flood frequency, other climate conditions (e.g. temperature extremes, precipitation), land use patterns, and traffic demands would cause the road to fail to meet those performance objectives?*" The team would interpret these sets of future conditions as scenarios that represent vulnerabilities of the current road design. Note that this step of the analysis relies far more on information the engineers are likely to possess – how their road would perform under a variety of future conditions – rather than information they may lack – patterns of future climate and economic growth in their region.

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

Finally, the engineers would evaluate which if any of these potential modifications are worth incorporating into the plans for their road. Some modifications may have sufficiently few "regrets" that they are worth adopting no matter what one thinks about the likelihood of future climate scenarios. However, other potential modifications may only prove worthwhile if particular combinations of future climate change and socio-economic conditions are judged sufficiently likely. For instance, the road may fail to meet its objectives if traffic on it increases by more than some level while flooding exceeds some threshold frequency.

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[3] The approaches described in this series by Casey Brown, Suraje Dessai, Nicola Ranger, and Tim Reeder also enjoy some similarities with RDM.

In such cases, the engineers now have a very specific set of questions – for instance "*Would we ever expect future floods to exceed some certain level more than once every few decades?*" – with which they can engage climate scientists and other experts. The RDM framework allows the engineering team to evaluate their vulnerabilities to climate change and to a broad range of socio-economic factors, and to consider potential responses while relying largely on information they have more readily available. Depending on the cost and effectiveness of their available options, the RDM framework may help them reduce their additional need for climate and other projections to a small set of focused questions.

The city might be spending billions of dollars on storms barrier, drainage, and sewage infrastructure construction intended to protect the city for decades. In contrast to the case of the road builders, the city likely has sophisticated models of the hydrology of their region and access to state-of-the-art regional climate projections. Nonetheless these models are not perfect, and planners rightly may worry that unanticipated changes in precipitation, sea level, and urban development patterns may cause the flood control systems to fail to function as anticipated.

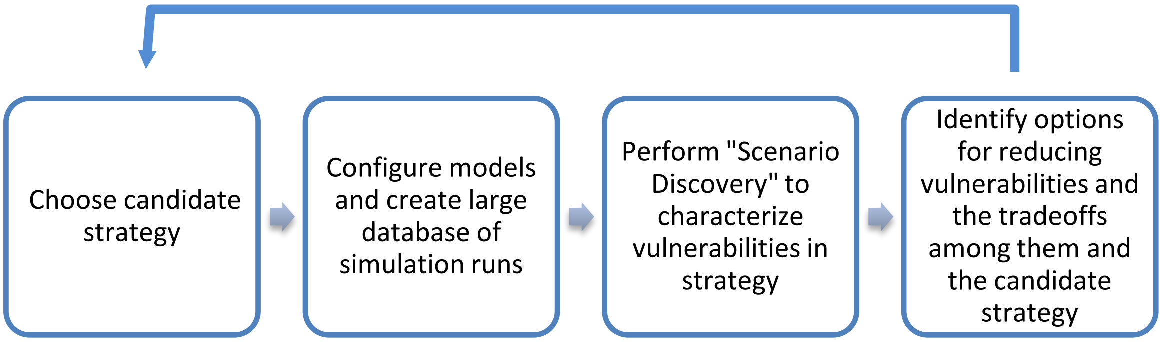

Figure 1. Steps in an RDM Analysis

RDM as Full Quantitative Approach for Decision Support

RDM also offers a full complement of analytic methods and tools to provide quantitative decision support for climate change adaptation efforts in developing countries. Imagine, for instance, a large, fast-growing coastal city in a developing country building a flood control system. This city might already experience extensive riverine and sea storm surge flooding. In the coming decades increased precipitation and rising sea levels could frequently inundate large portion of the city's population, placing the poor at particular risk and threatening new economic development in low lying areas.

To address this challenge with RDM, the city would follow a series of steps similar to those recommended for the road builders, as illustrated in Figure 1. The city planners would first begin with the current plan for the city's flood control system and any associated policies for land use and other factors. This plan might be based on the best-estimate projections of the detailed hydrology and climate models.

The city would next configure these simulation models to project the performance of this base case design over a wide range of alternative future states of the world, in addition to just the best-estimate case. Each case would represent a different combination of assumptions about future urban development patterns, future climate change, and the ability of the city to implement different elements of its flood control plan and land use policies. These assumptions reflect the types of uncertainties the city faces. The city might use its existing, detailed models to examine the performance of its flood control system in these many cases. Alternatively, it might develop simple simulations for this purpose that can interpolate among and extrapolate beyond the cases considered by the more detailed planning models.

Once it has conducted these many hundreds to thousands of runs with these simulations, the city planners would use statistical algorithms to identify and cluster future cases where the system is vulnerable – that is, when it fails to adequately protect the city's inhabitants and economy. The algorithm simultaneously identifies the common characteristics of each cluster of threatening cases (e.g. sea level exceeds a certain threshold, or population in a particular area rises by some level). This process, and the statistical algorithms used to conduct it, are called "scenario discovery."

These clusters concisely describe scenarios that city planners can use to consider potential weaknesses in their design and options for addressing those weaknesses. For instance, one such scenario might suggest that, even with the planned flood control system in place, crippling floods will become more likely if sea levels rise more than 50 cm and development occurs in currently undeveloped flood-prone areas. These scenarios would play roles in the analysis that are analogous to the scenarios that emerge from a traditional, qualitative scenario-planning process. However, the RDM scenarios have emerged from a systematic, reproducible, analytic process with quantified measures of merit, as opposed to being developed from qualitative brainstorming. This confers several key advantages to the RDM scenarios: they are more likely to include potentially surprising cases, they are better able to generate consensus among different stakeholders, and they provide more solid foundation for quantitative engineering and policy analyses.

Armed with this information, planners can next identify alternative plans for augmenting the flood control system and land use policies that might reduce the vulnerabilities that remain with the current plan. Such modifications might include changes to the design of the physical infrastructure – e.g. strengthening the flood defenses around certain neighborhoods – as well as non-structural policies such as restricting development in certain areas. The same models and scenario discovery methods can be used to project the performance of these alternative plans and identify any remaining vulnerabilities they leave and any new vulnerabilities they introduce.

The city can now use these simulation runs to compare the implications of their current flood control and its potential modifications, in particular asking which if any potential modifications provide sufficient benefit to outweigh any additional costs. This stage of the analysis generates tradeoff curves that will help the team consider how they might wish to balance potential changes to the current plan with the reductions in vulnerability such changes might provide. These tradeoff curves may suggest "probability thresholds," that is, the probability decision makers would ascribe to a vulnerable scenario in order to justify taking one of the corrective actions to address it. These probability thresholds can be compared to any available information, whether from scientists or local stakeholders, about the likelihood of various climate projects and development patterns that can help the city choose among potentially robust flood control plans.

Summary

RDM is being used by many natural resource agencies in the United States and other developed countries to support planning for climate change adaptation and to overcome many of the organization and implementation barriers that, with more traditional approaches, make it difficult to plan for climate change.[4] While these agencies typically use the full quantitative form of RDM, the principles of RDM can also be used qualitatively. These principles are: 1) reversing the order of traditional analyses to start with a proposed plan and characterizing uncertainties by their effect on the ability of the plan to meet its goals, 2) considering multiple views of the future, and 3) using a robustness criterion to evaluate alternative decision options. These principles offer a qualitative decision framework that can confer the benefits of RDM when a full analysis is not needed or not possible. The approach may prove at least as valuable in developing countries as it has proven elsewhere.

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[4] Brief summaries of many of these activities can be found at: http://www.rand.org/ise/environ/projects/water/water-resources-planning.html

References

Groves, David G., Robert J. Lempert, Debra Knopman, Sandra H. Berry, 2008: Preparing for an Uncertain Future Climate in the Inland Empire: Identifying Robust Water-Management Strategies, DB-550-NSF, RAND

Groves, David G., Debra Knopman, Robert Lempert, Sandra Berry, and Lynne Wainfan, 2007: Presenting Uncertainty About Climate Change to Water Resource Managers, RAND TR-505-NSF.

Lempert, Robert J. and Myles Collins (2007). "Managing the Risk of Uncertain Threshold Responses: Comparison of Robust, Optimum, and Precautionary Approaches." Risk Analysis **27**(4).

Lempert, Robert J. and Steven W. Popper (2005). High-Performance Government in an Uncertain World. High Performance Government: Structure, Leadership, and Incentives. R. Klitgaard and P. Light. Santa Monica, CA, RAND.