Climate Resilience in Concept and Practice:
ISET Working Paper 2

Only Death is Certain, Yet You Still Get Out of Bed in the Morning:

Or Observations on the Use of Climate Information in Adaptation and Resilience Practice

Lead author: Sarah Opitz-Stapleton

Contributing authors: Greg Guibert, Karen MacClune, Ken MacClune, Lea Sabbag and Stephen Tyler

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This publication is made possible by the support of the Rockefeller Foundation as part of the Asian Cities Climate Change Resilience Network (ACCCRN). ACCCRN aims to catalyze attention, funding, and action on building climate change resilience for poor and vulnerable people in cities by creating robust models and methodologies for assessing and addressing risk through active engagement and analysis of 10 cities in Asia. The ACCCRN program engages local level and national organizations in India, Indonesia, Thailand and Vietnam, and was conceived and launched by the Rockefeller Foundation in 2008.

As part of ISET, the authors have been involved in shaping the overarching conceptual frameworks, activities, and results described here. Likewise, our interpretation of the ACCCRN experience is shaped by our deep involvement with it. Views and opinions expressed within do not necessarily reflect the position of all ACCCRN partners nor of the Rockefeller Foundation. While we gratefully acknowledge the contributions by many colleagues, responsibility for any errors or misinterpretations lies with the authors alone.

Any comments or questions on this paper can be directed to info@i-s-e-t.org.

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Observations on the Use of Climate Information in Adaptation and Resilience Practice

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Forward

Perceptions about partners' abilities to find, interpret, and utilize climate information in the various ACCCRN contexts is influenced by an individual's or organization's understanding of climate information and conceptions toward how it should be used. All ACCCRN partners were presented with a questionnaire designed to elicit their perceptions on: 1) the process by which climate information was utilized in each country and/or city context; 2) the evolution in their understanding of how climate information *should* versus *could* have been used at various points in the project; and 3) their recommendations for what they think should be done differently in accessing, interpreting, translating, communicating and using climate information at various stages of the adaptation process.

I have tried to supplement perceptions from the questionnaires with my (and other ISET staff's) experiences of working with various partners, notes from the shared learning dialogues/workshops, and correspondence, such as emails or notes from conference calls. All the responses to the questionnaires are held in strictest confidence and sources of information are concealed. This is done to protect the honesty, integrity and ability to continue to speak freely of those who felt able to respond to my inquiries. Only my opinions and observations will be directly acknowledged in this report. Additionally, the information in this report is contextualised by my observations and experiences in being a climate scientist, and in interacting with other climate scientists concerned with effective information communication.

Executive Summary

The role of climate information is an increasingly important but poorly understood topic in the field of adaptation. Originally designed to test and demonstrate the theory of climate change, climate projections have only recent been asked to serve as a basis of decision making and planning. Globally, there are many unanswered questions for planners about the nature of climate change and what information is needed to conceptualize and frame their specific approach to dealing with change. Examples of planning efforts from the Asian Cities Climate Change Resilience Network (ACCCRN) are highly illustrative of the global challenge of integrating climate science into adaptation, common pitfalls and misunderstandings by both producers and end users of climate information, and tools and next steps in forging more effective communication of climate information.

This paper opens with a review of climate science concepts, terminology, and linguistic challenges in communicating climate information. It also describes key sources of uncertainty in climate change projections, which presents a critical concern and frequently, a point of confusion for those attempting to plan for climate change. Even among climate planners there is no consensus and little common understanding about the appropriate role for climate information in adaptation work. ACCCRN and related experiences in adaptation planning reveal and help refute a number of misleading common conceptions:

"More information about historical and future climate is always more helpful in making adaptation decisions, and decision-makers cannot act unless uncertainty is low." Climate science is evolving, and our knowledge of climate systems is likely to become more sophisticated over the coming decades. However, climate projections will always be uncertain, and they will never produce the kinds of probabilistic data that planners have historically used to make decisions. ACCCRN partners at regional, national, and local levels have found this concept confusing and frustrating, and a great deal of effort has been devoted to helping them absorb and grasp its implications. Adaptation planning requires comfort with planning for a number of possible future conditions, acknowledging uncertainty and the importance of multi-criteria assessment for identifying and prioritizing adaptation options.

"Climate information is readily available and pertinent to the desired scale and timeframe for adaptation decision-making." Almost universally, ACCCRN partners indicated that they expected city/location specific historical climate data and high resolution climate projections to be available at the beginning stages of the program, easily accessible and in a useable format for the vulnerability and risk assessments and shared learning dialogues. This was not and rarely is the case for new local adaptation efforts. At the early stages of ACCCRN, moreover, there was no clearly articulated expectation between international and national-level partners as to who bore primary responsibility for collecting historical climate data and climate projections.

For ACCCRN partners, coordinating historical climate data collection and climate projections to use in vulnerability assessments emerged as a primary research activity. These activities encountered various obstacles, including a dearth of local-scale historical information (not infrequent in developing contexts) and bureaucratic delays in identifying and accessing this data. The ACCCRN experience demonstrates that difficulty in acquiring data is as much due to lack of data as it is to bureaucratic hurdles related to data request processes and politics around which datasets are officially sanctioned for release and use. In addition, much information is tailored to the discrete climate science community, and is available only through archive sources and or peer-reviewed journal articles. A lack of adequate historical data leads to limited ability to validate climate model performance at any scale. Identifying plausible future climates and climate impacts is further compounded by a lack of high-resolution projections for the regions in question, as also is often the case in developing contexts.

In the ACCCRN cities, the requirements of climate information collection and analysis generally left little time for dialogue and clarification of partners' understanding before it was in turn presented to local partners at the city level. Time constraints also contributed to the heavy emphasis in vulnerability assessments on investigating current vulnerabilities and how these are likely to be exacerbated by climate change, and only minimal focus on new scenarios of vulnerability and risk unrelated to current issues.

"Once released by climate scientists, the decision-maker is responsible for accessing, interpreting and using climate information in whatever format it is presented." In ACCCRN, there were still quite divergent capacities for accessing, understanding, and utilising climate information among project partners at all levels. The ACCCRN experience highlights typical stumbling blocks that local partners encounter in interpreting climate information. These problems reveal gaps in communication and openness between the producer-end (climate scientists) and user-end (local planners and decision makers) of climate information.

Common issues in ACCCRN included:

- Difficulties conveying the information to city partners in a meaningful manner that adequately expressed the uncertainties and did not treat the projections as the factual future. This led to a few instances of over-interpreting data and higher levels of confidence in the data than were warranted.
- A lack of understanding of difference between climate projections and climate impacts. Many partners expressed the desire to know how climate change might impact their cities, and expected climate scientists to be able to provide the localised impact data, without realising that while impacts research builds off of climate model research, the two are separate.
- Data were frequently released in the same file format as they would be given to fellow climate scientists, rather than in a format easily interpreted by non-scientists. Often, non-climate scientists feel "technically inadequate" when they are perceived as not being able to utilize information provided by climate scientists. This leads to a reluctance to voice concerns or request assistance in accessing, interpreting, and using information.
- Climate information providers did not supply explanations as to how the historical data and climate projections were produced or what assumptions, biases, and uncertainties were associated with the data. This may reflect a more general dilemma in climate science globally: the reluctance of climate scientists to share assumptions used to generate projections or the uncertainty inherent in the data, for fear that non-scientists will dismiss "uncertain" data or that uncertainty will be used as an excuse for inaction.
- The communication gap between producers and users leads to a mismatch in what is needed and what is made available. Climate information is typically presented in a form that is of limited value to planning processes and timeframes—for instance, average monthly temperatures rather that extreme temperatures—because the climate science community does not understand important thresholds and impact areas of concern to different users. Due to a lack of familiarity with the complexities and nuances of climate information, users are in turn typically unable to frame requests to climate scientists in a way that would help them understand user needs.

Overall, experience has repeatedly shown that users want and expect climate scientists to have the information they seek and to explain how to use it. By the same token, potential users who do not seek to educate themselves and connect with an information producer might not be making the best decisions. Building communication and a sense of shared responsibility for user end applications will be critical for successful, locally driven adaptation work.

"Climate science and the information it produces are apolitical, objective and above ethical discourse." Climate science lies very close to the boundaries between science, policy, and public discourse because of the far-reaching implications of climate change, mitigation and adaptation actions. Yet many scientists feel uncomfortable with acknowledging the politics of climate science processes while trying to maintain objectivity, openness, scepticism, disinterestedness and distance from politics that are in fact critical to science. The paper discusses examples from the IPCC and national governments. In the ACCCRN experience, this was reflected in bureaucratic barriers to accessing meteorological data and/or government control over the use of scenarios for planning.

"Decision making on development strategies, infrastructure and investment readily integrates and benefits from physical science information." Early adaptation frameworks from the IPCC envisioned a top-down, science driven approach to adaptation planning. This approach relied heavily on access to historical climate data and future climate projections. It has become clear that this type of planning is ill suited for local realities in which data do not exist, are difficult to access, or are not applicable for key types of decisions. Furthermore, because the impacts and the strategies or responses for dealing with those impacts are inherently local, the top-down climate science approach is not well suited for learning from or incorporating the local experiences of individuals and communities. Preliminary adaptation planning experience indicates the need for strong, bottom-up approaches that start with assessments of current vulnerability and a critical examination of the opportunities, constraints, and experiences that guide adaptation behaviours. This bottom-up approach then needs to be meshed with the top-down climate science approach. There are many important questions regarding monitoring and assessing adaptive strategies that are only just emerging among practitioners and in research communities.

These above observations yield of recommendations for reconsidering and refining the role of climate science in adaptation.

- There is a crucial need for "climate extension services": the development of specialized groups who can serve an intermediary role, helping to translate climate science into information valuable to user groups; and helping user groups to articulate information requests in technical terms. Such brokers would need to bridge disciplines, and have expertise in climate science and statistics, data management and presentation, as well as broad familiarity with key user needs and strong communication skills.
- Adaptation decisions should rely on evidence from science, but they are not solely scientific decisions. They always require the assessment of values and priorities that reflect local cultural, environmental, economic and political priorities. Climate scientists and other expert information providers have important roles to play in adaptation decision-making, but they should not drive the process.
- Adaptation programs should be premised on shared learning and early engagement between knowledge holders and other stakeholders, including donors and managers. This is essential for assessing adaptation goals and concerns, and starting dialogue between groups so as to understand information gaps, needs and assumptions. Until members of an adaptation project have a shared understanding of climate information and products and their availability, it is difficult to know how to make climate products useful to them or recommend what information (including non-climate related data) is needed, when and how it can be used in the program or intervention.
- Dialogue and shared learning require a significant time commitment and are unlikely to be effective as one-off interactions.

This paper concludes by presenting a set of web-based climate information resources that might be useful for local adaptation planners and researchers. These resources were selected based on criteria such as explanation and accessibility of scientific concepts; presentation and formatting in a manner that is meaningful and practical; and transparency about data, methods, uncertainties, limitations, and appropriate applications.

Key Points

Diverging Misconceptions

- More information about historical and future climate is always more helpful in making adaptation decisions.
- Decision-makers cannot act unless uncertainty is low.
- Climate science and the information it produces are apolitical, objective and above ethical discourse.
- Once released by climate scientists, the decision-maker is responsible for accessing, interpreting and using climate information in whatever format it is presented
- Climate information is readily available and pertinent to the desired scale and timeframe for adaptation decision-making.
- Decision making on development strategies, infrastructure and investment readily integrates and benefits from physical science information.

Common Observations

- Despite frequent assumptions to the contrary, there is no consensus and little common understanding, either by climate scientists or those engaged in adaptation work, about the appropriate role for climate information in adaptation work. What information is needed to support adaptation? How should it be presented? When can and when should it be used in adaptation processes?
- Access to quality information at a useful scale for adaptation planners is difficult, even with a number of resources now available online.
- Non-climate scientists have limited capacity to assess climate information and determine its source, quality, the assumptions and uncertainty associated, and the contexts in which that information can be used most appropriately.
- Non-climate scientists are made to feel "technically inadequate" when they are perceived as not being able to utilize standard information provided by climate scientists. This leads to a reluctance to voice concerns or request assistance in accessing, interpreting and using information.
- Climate scientists are often reluctant to inform those who request information about the assumptions used to generate projections, or the uncertainty inherent in the data. Some of this is related to a fear that non-scientists will dismiss data if assumptions and uncertainty are disclosed, and partly this is a fear that uncertainty will be used as an excuse for inaction.
- Climate information is typically presented in a form that is of limited value to planning processes and timeframes because the climate science community does not understand important thresholds and impact areas of concern to different users.
- Similarly, users are typically unable to frame requests to climate scientists in a way that would help them to see how existing data could be usefully presented.
- Global-scale information overload is occurring; at the same time, in many developing countries there is a dearth of local-scale historical information, and limited ability to validate climate model performance at

any scale. This is compounded by a lack of high-resolution projections for many developing countries, and difficulty in interpreting the uncertainties in projections that exist.

- Climate science is evolving: with a growing investment in both observation and modelling, as well as paleoclimatology, our knowledge of climate systems is likely to evolve rapidly over the coming decades. This will lead to revision of projections and expectations, as well as some reduction in uncertainty. However, uncertainty will never be eliminated from projections.

Practical Suggestions to Make Climate Information More Useful in Adaptation

- There is a crucial need for "climate extension services,"[1] the development of specialized groups who can serve an intermediary role, helping to translate climate science into information valuable to user groups; and helping user groups to articulate information requests in technical terms. Such brokers would need to bridge disciplines, and have expertise in climate science and statistics, data management and presentation, as well as broad familiarity with key user needs and strong communication skills.
- Adaptation decisions should rely on evidence from science, but they are not solely scientific decisions. They always require the assessment of values and priorities that reflect local cultural, environmental, economic and political priorities. Climate scientists and other expert information providers have important roles to play in adaptation decision-making, but they should not drive the process.
- Adaptation programs should be premised on shared learning and early engagement between knowledge holders and other stakeholders, including donors and managers. This is essential in order to figure out adaptation goals and concerns, and start dialogue between groups so as to understand information gaps, needs and assumptions. Until members of an adaptation project have a shared understanding of climate information and products and their availability, it is difficult to know how to make climate products useful to them or recommend what information (not just climate) is needed, when and how it can be used in the program or intervention.
- Dialogue and shared learning require a significant time commitment and are unlikely to be effective as one-off interactions.

This paper concludes by presenting a set of web-based climate information resources that might be useful for local adaptation planners and researchers. These resources were selected based on criteria such as explanation and accessibility of scientific concepts; presentation and formatting in a manner that is meaningful and practical, transparency about data, methods, uncertainties, limitations, and appropriate applications.

1 The analogy is to agricultural extension services, which are familiar in both developed and developing countries. Of course, food producers will be one of the most important user groups for climate information, where both functions of climate extension (interpreting likely climate variability and change for farming applications) and agricultural extension (introducing production technologies better suited to changing climatic conditions) will need to be combined.

General Communication Confusion and Discomfort

Introduction

Large-scale adaptation and resilience planning projects have only recently begun to emerge as global climate discourses begin to acknowledge the need for adaptation alongside mitigation. These projects have proven daunting, not least because some of the basic questions surrounding climate change and adaptation have yet to be answered with any real consensus in either the formal academic fields or amongst practitioners. These questions include, and are addressed in the other working papers in this series:

- What is climate resilience?
- How do we assess when climate resilience is needed and occurring?
- When does an action, policy or intervention become different from development that incorporates principals of disaster risk reduction and sustainable and ethical ecological management and truly move into the realm of climate resilience? Is there really a continuum?
- When can an action, policy or intervention actually be described as contributing to climate resilience?

Buried deeper still in these questions are other issues concerning the nature of climate change and what information is needed for decision-makers to conceptualize and frame their specific approach to dealing with change. Such questions include:

- Where to find location-specific climate projections?
- By what criteria does one judge the reliability of either historical or future climate information?
- What are the assumptions and uncertainty associated with particular sets of information?
- How can decision-makers deal with those uncertainties in analysis and decision-making?
- What are the appropriate questions that decision-makers and adaptation/development researchers need to ask climate scientists?

In the early 1990s, before the topic of climate change entered wider discourse, it was framed largely as a scientific question because most of the people concerned with understanding climate change were physical and atmospheric scientists. The prime concern for most climate scientists was *proving* that climate change was occurring, the extent to which humanity was responsible, and developing "credible" models so that people and governments would pay attention and 'do something'. To the extent that understanding climate change impacts was an area of research and interest at all, it was a distant, secondary priority and focused almost exclusively on physical impacts. The ramifications of climate change to people, human systems and ecosystems were rarely explored, except to justify to policy makers the need to reduce emissions. Mitigation, and using climate science to support the need for immediate mitigation, understandably remains the highest priority. However, in the past decade, there has been a growing recognition that adaptation is critical and unavoidable due to changes in the atmosphere-land-ocean systems that have been instigated and will continue even if emissions were to stop.

2 For example, see the Weather and Society*Integrated Studies "community" - http://www.sip.ucar.edu/wasis/ or read the latest IPCC (2007) Working Group II, Chapter 2 - http://www.ipcc.ch/publications_and_data/ar4/wg2/en/ch2.html.

The idea of communicating climate information and understanding the role it *could* and *should* play in decision-making and adaptation planning did not enter into the purview of most climate scientists (personal communication with multiple climate scientists). It is still not a concern to most climate scientists, although there are a growing number of concerned[2] scientists who are actively working to try to address the issues associated with communication and information usability. At the most recent World Climate Conference in 2009, participants affirmed the need for stronger partnerships between climate information producers and users, and in making the information more user-oriented than has historically been the case. A Global Framework for Climate Services has been proposed to guide climate scientists in making information more usable and accessible, however, much of the framework is still focused on the production of information and model improvement (WCC-3 2009).

This working paper chronicles the perceptions and processes of utilising climate information in the Asian Cities Climate Change Resilience Network (ACCCRN), an initiative conceived and financed by the Rockefeller Foundation and intended to support climate adaptation actions in Asian cities. I will employ the lens of the wider debates and discourses occurring within the climate science and policy communities to analyze the ACCCRN context. It starts with some of the most common misconceptions about climate information and decision-making. I offer observations from other initiatives. These observations suggest that ACCCRN experiences are not unique and that there is a need for more systematic and effective communication of climate information. Because of the increasing role and prevalence of web-based climate products, I conclude with some suggestions of key criteria for credibility and communication and suggest a selection of websites that appear to meet these criteria.

Myths and Other Stories about Climate Information and Decision-Making

There are a number of myths with considerable influence in the process of climate information production, dissemination and usage, only some of which are covered here. Many of the myths and misconceptions associated with science, information, roles, communication and decision-making are not limited to just climate information. The field of policy science has been investigating many of these issues for a while, and making recommendations for a number of decades (see Sarewitz 1996 or Averill et al. 2010), which are sometimes implemented and sometimes ignored.

Lost in Translation and Speaking in Tongues

A key challenge to communicating climate change science and translating information outputs is simply that the language used by climate scientists has very different meanings than the language used by non-climate scientists, even when they are the same word. Terms such as: *forecast, prediction, projection, scenario* or *uncertainty* have very different meanings to climatologists and meteorologists than they do to lay people and furthermore, they may be inconsistently understood among scientists and disciplines. Inconsistencies in language use between scientists muddle the field and add confusion for non-scientists (Bray and von Storch 2009; Opitz-Stapleton 2010; Klemens 2009; MacCracken 2001; Connolley 2007)[3]. Below are what I believe to be the clearest climate science definitions of the words that are commonly encountered in accessing climate information, as compiled from a variety of sources. These definitions are not written from the perspective of lay terminology, but rather from the perspective of climate scientists to provide a sense of what climate scientists generally mean when using these terms. However, it is important to remember that there remains significant confusion even among meteorologists and climatologists over this terminology, which underscores the importance of dialogue between those engaged in adaptation work and climate scientists in order to find common language and understanding before an adaptation project commences.

3 For different conceptions/confusions about "predictions" versus "projections", refer to: http://sciencepolicy.colorado.edu/zine/archives/1-29/26/guest.html or http://scx.sagepub.com/content/30/4/534.short or http://scienceblogs.com/stoat/2007/08/projection_prediction.php or http://modelingwithdata.org/arch/00000024.htm

Climate Science Definitions: *What a climate scientist likely means when she/he says...*

Prediction: a probabilistic statement that something will happen in the future based on what is known today. A prediction depends only on the current and historical conditions of weather and climate, not on any guesses about future concentrations of greenhouse gases. The statement of probability – such as 70% chance of rain tomorrow – is a statement of how certain the scientist is the event will occur.

Forecast: a statement about the "best prediction" based on experience, knowledge of all the predictions and the credibility of the person making the forecast. For example, a TV weather forecaster might say that there is a 70% chance of rain tomorrow afternoon by 3pm because 70% of the model predictions indicate rain, and cold front is moving in overnight.

Projection: a statement about the possibility/likelihood of something happening, given both the starting conditions (what is happening today) and a certain set of plausible, but not necessarily probable, future conditions. It is an ***If*** this happens, ***then*** this might happen. It is very hard to assign probabilities to projections because projections are conditioned on scenarios of things like population growth or rates of deforestation, which are educated guesses.

Scenario: an educated guess about possible future conditions or stories based on research. The greenhouse gas (GHG) emissions used in climate models are scenarios of potential future levels of GHGs, based on other scenarios of population growth, economic growth, technology and land-use. The GHG scenarios are concerned with long-term trends, not short-term fluctuations.

Uncertainty: the inability to say *exactly* how climate will change in a particular year in the future for a particular location (or even the planet).

Probability: a statement about the odds of whether an event will happen, based on knowledge of the constraints surrounding that event. For example, what are the odds/probability of rolling a 4 on a 6-sided die? Because there is some knowledge about the constraints and past experience about how the event works, there is some certainty about the event and the odds can be *verified*.

Likelihood: a subjective assignment of possibility to an event for which one has little knowledge and no ability to verify the results. For example, you have the results of a standardised math exam from one class at one school, and you draw one result and find that it is a 98%. What are the odds that the mean score of the class' test results is 75%? Because there is no information about the distribution of that class of students' test scores, the odds of the event being one value and not another cannot be verified. All the information that exists is the single draw and limited knowledge/past experience about test score distributions that makes it impossible to definitely describe the constraints around the event or any future event. *The key distinction between likelihood and probability is that likelihood can't be verified because it is based on very limited knowledge and usually used to describe future events not in the realm of common experience.* [I am not going to get into a discussion on Bayesian versus frequentist definitions of probability and likelihood, because for the moment, many climate scientists use the frequentist definitions]. *Possibility* and *subjective probability* are other terms that mean the same as likelihood.

From the above list of definitions, it is apparent that Global Climate Models (GCMs) and Regional Climate Models (RCMs) produce *projections* and not predictions because the models utilize scenarios of potential GHG emissions to see what might happen to the climate system if a particular emission scenario is used. The words "prediction" and "forecast" are most appropriately used with meteorology because weather models are conditioned

ISET worked with Utthan, another NGO, on a community-level adaptation project in coastal Gujurat, India. During dialogues with villagers, local participants highlighted 3 aspects of climate where they believe changes are occurring:

1. Increases in the number of rainy days and rainfall intensity.
2. Extension of the length of the winter cold season, and
3. Higher levels of variability between seasons.

The perception of a lengthening in the cold season highlights the difficulty in communicating weather and climate information in Hindi. During the 2007-2008 winter cold season, a cold spell lasted a little longer than cold spells in previous years. Actual weather records for the region, and for much of India, indicate a shortening of the cold season and fewer cold spells over the past few decades. However, due to different conceptions of weather and climate, one recent incident is perceived as an indicator of "climate change" to villagers, even though an individual event can't be construed as climate change in the Western scientific construct.

on current and historical conditions, not on scenarios of possible futures. This is a very important distinction to communicate in climate adaptation work – because it means that probabilities cannot be assigned to any of the climate model outputs. At best, the likelihood or possibility of a particular projection occurring in the future can be discussed and must be based upon: 1) Knowledge about the model that produced the projection – its assumptions, how well it can replicate key features of the historical climate for the region of interest; 2) Which emission scenarios were used to make the projection(s); 3) The subjective degree of confidence in the projection, based on the decision-maker's risk preferences; 4) The types of communication with the climate scientists who produced the information and their credibility; and, 5) The decision-maker's understanding of the severity of the implications and impacts of that projection for the area, group of people, or timeframe of interest (Kinzig et al. 2003; Gay and Estrada 2010; Dessai et al. 2009).

Adding to the confusion of disciplinary differences and lack of common climate terminology is the reality that in many languages, there is no substantial differentiation between the concept of climate, season and weather. Because the mental mindscape of these cultures does not distinguish between these, there is often only one word used interchangeably for talking about these concepts. In Hindi, for example, *mausam* means weather, season and climate. In Thai, อากาศ *(aa-gàat)* signifies both weather and climate, although there about 13 different terms used for season. The cultural constructions and misunderstandings of cultural constructions are real barriers for communicating climate change concepts and information to people – local government, fishermen, farmers, etc. – especially across languages.

"There are the Known Unknowns and the Unknown Unknowns[4]..."

One of the most frequent requests from decision-makers at all levels, both within the ACCCRN program and in other contexts, is for greater accuracy and precision in location specific climate projections. "Some delegates wondered about the accuracy of these climate change scenarios, sea level rise and hydrological models" (Quy Nhon SLD2 Report). Uncertainty in climate change projections and the inability to precisely know the future results in the inability of climate scientists and their research products to indicate exactly how much rain is likely to fall in a location in Gorakhpur, India on July 23, 2050 or exactly how the Asian Monsoon system will change in the future, due to the complex land-ocean-atmosphere dynamics that govern that system.

4 Attributed to Donald Rumsfeld

There are multiple sources of uncertainty in climate change projections. The three primary sources are:

1. Projections of human change, growth, and emissions: Simplified assumptions are made regarding future energy pathways and development regimes whose effect on GHG emissions would alter both the foundational design and outcomes of many of the scenarios. Additionally, human land-use and land-use change, especially for food, fuel, and forestry are poorly incorporated into climate and integrated assessment models, but play significant roles in terrestrial-atmospheric interactions. International politics and trade agreements will greatly influence national and global energy choices. The understanding and trending of all these factors requires constant adjustment and integration into the scenarios used to drive climate models and integrated impact assessment models. The combination of so many assumptive projections of changing conditions as well as drivers of climate change mean that uncertainty is compounded throughout the modelling effort.

2. Climate models (or any model, for that matter) are only approximations of reality: Some of the climate physics – the interactions between the land, ocean and atmosphere – are well understood, but others are not. Even those interactions that are well understood are not necessarily represented well in models because they are non-linear processes and difficult to describe mathematically. The more the climate system is studied, the more we are beginning to realize how complex it actually is and how much we have to learn. Most interactions are represented by mathematical equations. Due to computational resources or incomplete understanding, other interactions are merely represented by parameters. Finally, the resolution of climate models is too coarse to capture local climate processes at this time. When climate projections are downscaled to the scale of 5 – 10 km, the introduction of error in the model increases through the merging of extremely small-scale processes with large-scale climate processes.

3. Each GCM and RCM models these physical processes in slightly different ways and uses different sets of starting information: This variability is why different models will give different climate projections for the exact same scenario. Furthermore, some models are better at replicating the historically observed climate signals in different regions of the world than others. Models that are better at replicating the mean Asian monsoon behavior from 1960-1990, for example, provide greater subjective confidence that their climate projections are more likely to accurately capture future conditions than a model that does not do a good job of capturing the historical and current monsoons. Confounding this simple rule however, is that since no one single model is better at projecting the entire future earth condition than all the others, this could indicate that even models that poorly resolve historical regional trends may ultimately be more accurate in determining future regional projections. Only time will tell. Finally, it is important to remember that no model, ensemble of models, or average of model results, will ever produce a truly accurate prediction of the future earth climate system, whether regional, local, or global.

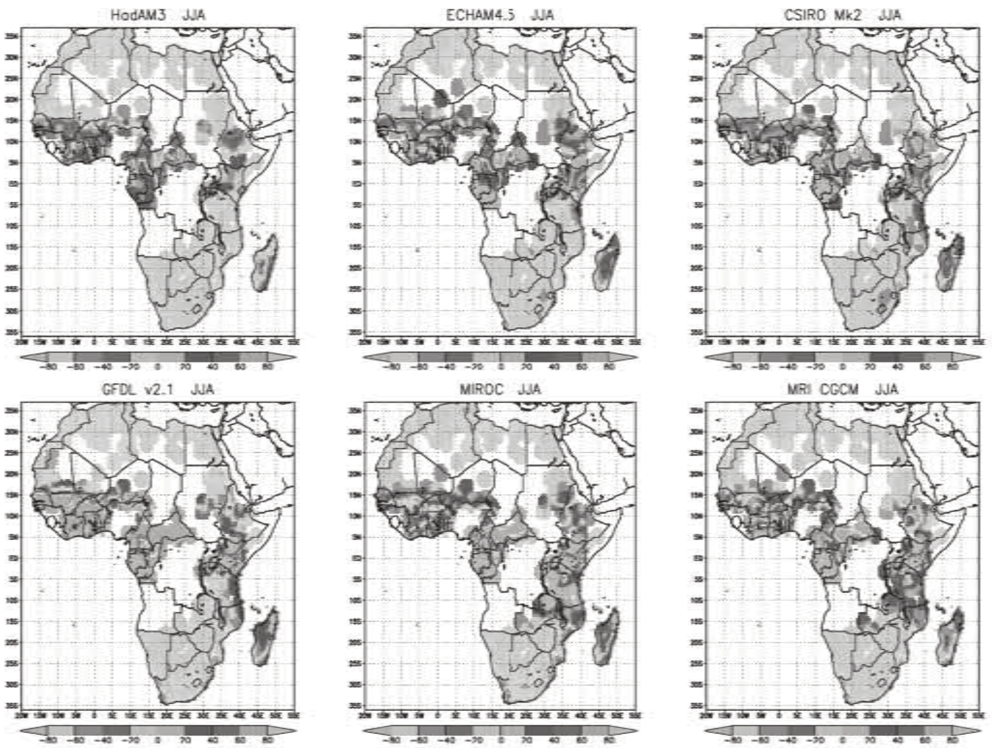

Figure 1: Six different climate projections of changes in mean June-August precipitation for the periods of 2070-2090 (top 3 models) and 2080-2099 (bottom 3 models) compared to 1960-1990 for Africa using the A2 scenario, from 6 different GCMs. Each projection is slightly different, highlighting the need for using multiple models to acquire both trends and ranges (figure adapted to grayscale from Christensen et al. 2007: 870).

The most difficult aspect of building urban climate resilience, or climate resilience at any context or scale, is learning to accept and deal with the uncertainty generated by the factors listed above. Because models carry unavoidable uncertainty, the level of which may be unknown and not easily quantified, vulnerability assessment and perhaps resilience planning[5], may benefit from discussing climate information accuracy and reliability in terms of trends, ranges and model bias.

Trends – the direction in which a variable is moving over time. For example, is seasonal precipitation for the Mekong Delta expected to increase by 2099?

Ranges – When the projections from a number of models are compiled, what is the spread in their projected values for the precipitation? The range of the models could be something like -8% to +23% change in annual precipitation by 2030 for a particular city, when compared to the average annual precipitation in 1960-1990. Ideally, one would also like ranges for changes in intensity and frequency of extreme events, or seasons, but unless sufficient, high quality historical data exists for a city, it is difficult to extrapolate ranges of change on smaller temporal scales.

5 The appropriate role of climate information in resilience planning is debatable. Resilience planning should, ideally, incorporate information from vulnerability and risk assessments, values and economic preferences from stakeholder engagement, and the development of multiple criteria for identifying, prioritising, implementing and monitoring and evaluating interventions. Climate projections and climate impact scenarios may or may not play a role in informing the vulnerability and risk assessments, multi-criteria analysis and stakeholder preferences for a particular intervention.

Bias – the amount by which a model over or underestimates a variable, such as rainfall or temperature, during a model simulation when compared with historical observations of that variable. Model biases may or may not carry forward into future projections, and require acknowledgement in climate projections.

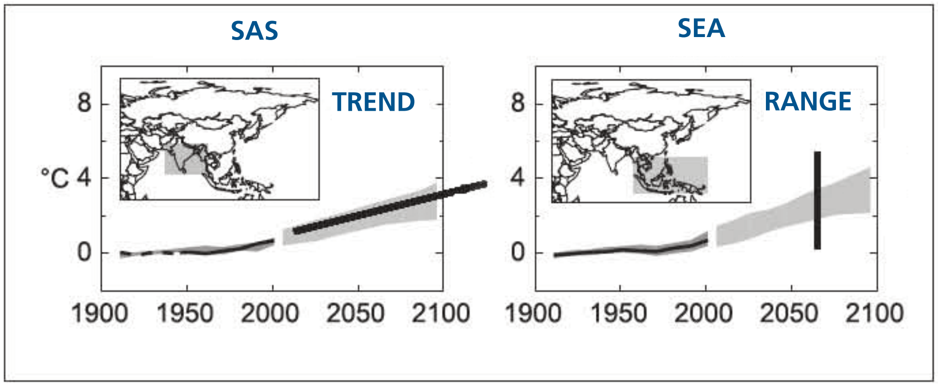

Figure 2:

Mean projected annual temperature changes for South and Southeast Asia. These pictures represent a compilation of projections from the 20+ GCMs.

Adaptation processes will be more robust against a variety of potential changes if they consider the trends and ranges of multiple projections rather than a single, specific projection. Many climate scientists are fairly confident that climate change will fall somewhere within the range of the existing model projections, at least up until about 2050. What diminishes confidence in the projections beyond 2050 is lack of knowledge about the future evolution of population, technology, policies and emissions. If these factors continue to increase faster than the A2 SRES scenario, as they have in the past decade, the trends and ranges of the projections could be much worse than currently projected – temperatures will likely be higher, storm intensity and frequency greater, and there will likely be much more variability in precipitation.

Finally, the scenarios used to drive climate models, and the models themselves, are constantly being updated, thereby altering the levels of uncertainty embedded in each model and changing the degree to which scientists have more or less confidence in the results. All models projections that will be included in the next IPCC AR5 assessment of 2013, for example, are being driven by an entirely new set of scenarios known as *representative concentration pathways* (RCPs). The RCPs will allow a much broader range of emissions, policy, technology, and socio-economic scenarios to be tested than was allowed using the SRES scenarios. There are some critical differences between the RCPs and the former SRES scenarios (Moss et al. 2010; Moss et al. 2007).

The RCPs are based on the amount of energy being trapped by the earth's atmosphere (radiative forcing) in order to map a broad range of possible climate outcomes. Any number of different combinations of GHG emissions, policy, technology and socio-economic scenarios can be created to lead to the end result of 4 different energy amounts by 2100. Because of this, climate modellers and integrated assessment/vulnerability modellers will be able to use any combination of scenarios they choose. The ability to test a broad range of plausible pathways will lead to numerous possible future outcomes according to the models. This implies, although it will not be known until many model results are available, that the uncertainty surrounding climate projections and impact assessment is likely to *increase* in the IPCC AR5, not decrease. In response to pressure from policy makers, the climate community will release projections for the near-term (2020-2035) and the long-term (2100-2300). It is hoped that the near-term projections will prove more useful to decision-making timeframes. At the same time, by running the projections much farther into the future, climate scientists are allowing policy makers to see when and how mitigation policies might begin impacting the climate system.

The Information Janus: Duelling Expectations

The confusion in language and surrounding concepts of uncertainty is reflected in misplaced expectations of climate information and how it can support adaptation efforts. One dominant view that arises is that "better" information is needed for decision-making, although there is no clear agreement as to what constitutes "better". This is often expressed through two sentiments:

- More precision is necessary before adaptation decisions can be made:

  "Considerably improved predictions of the changes in the statistics of regional climate, especially of extreme events and high-impact weather, are required to assess the impacts of climate change and variations, and to develop adaptive strategies to ameliorate their effects on water resources, food security, energy, transport, coastal integrity, environment and health. Investing today in climate science will lead to significantly reduced costs of coping with the consequences of climate change tomorrow" (World Modelling Summit for Climate Prediction 2008: 1).

- Decision-makers need probabilistic information. Scientists have a different understanding of probability than many decision-makers, relying on repeated trials and experiments to determine the frequency with which something might occur. However, in many real world situations it is not possible to determine the probability of the outcome because in the future conditions are novel to human experience and cannot be tested for accuracy or validity. Instead, many people rely on their knowledge and the information they have to subjectively determine the tradeoffs between one course of action over another. In this sense, many policy makers rely on *likelihood* to make decisions and not the probabilities scientists are used to trying to provide (Kinzig et al. 2003; Gay and Estrada 2010).

These sentiments are symptomatic of the fundamental misunderstanding and lack of dialogue between those producing climate information and decision-makers who would use it at all levels. Decision-making, whether at a personal financial level to national policy, is fraught with uncertainty. For example, economists cannot exactly predict what next year's GDP growth rate will be – they base their projections on observations of current conditions and scenarios of what they think might happen in the next few years – and policy makers decide national budgets utilizing economic projections despite their considerable uncertainty.

Because many climate scientists do not know how decision-making processes occur and are not involved in adaptation research, there is a common perception by the larger climate science community that adaptation cannot happen until "accurate and precise" climate projections are available (see the World Modelling Summit for Climate Prediction - http://wcrp.ipsl.jussieu.fr/Workshops/ModellingSummit/DocumentList.html - or the World Climate Research Program's statement on regional climate modelling and downscaling - http://wcrp.ipsl.jussieu.fr/SF_RCM Terms.html). The focus of funding within the climate community remains on modelling and in improving observation, with secondary attention to communication of results in meaningful formats to positively affect adaptation related decision making.

There is a predominant position that the role of the scientist is merely to provide information; it is up to the users to know how to interpret it. "To assess uncertainty – to judge its magnitude and find out its origins – is ultimately the responsibility of the decision maker. Climate research simply provides all the relevant information" (Kropp and Scholze 2009: 28). The misconception from the science side is that more information is necessary, but that scientists are not responsible for how the information is interpreted and utilized. Furthermore, many climate scientists are so removed from adaptation research that they do not really comprehend the opportunities and constraints influencing individuals' behavior or what aspects of people's lives and livelihoods are vulnerable to climate change. These conceptions culminate in climate scientists who expect decision-makers (and not understanding the nuances between different decision-makers) to bear full responsibility for navigating climate products, uncertainty and making decisions.

Yet, experience has repeatedly shown in diverse cultural conditions such as those in ACCCRN, that users, including decision-makers, want and expect climate scientists to have the information they seek and to explain how to use it. One common thread of conversations with government and NGO representatives at the ICLEI Resilient Cities 2010 conference in Bonn, Germany was that they do not know where to get information, how to interpret it, or how to use it to inform their decision-making and a frustration that climate scientists are not more forthcoming with that information. The development community often has limited familiarity with physical sciences and low physical science literacy, contributing to their frustration with and low capacity to use the climate information as provided. The currently low capacity of many decision-makers and adaptation researchers to understand the complexities and nuances of climate information directly influences the wants, needs and expectations of these users with regard to information. By the same token, many climate scientists have little training or expertise in social, policy or development sciences. The climate science community's limited capacity and ability to devote more time to understanding and anticipating user wants, needs, and expectations influences how information products are conveyed.

Part of the question concerning responsibility for making and utilising climate information appropriately is related to the timeframes of climate projections versus the timelines crucial for decision-making. Climate scientists have focused on the more distant future (2070-2100) because, in climate science framing, climate change is about the long-term changes in the trends and behavior of weather AND it will not be easy to distinguish when an event was influenced by climate change until there is a statistically long enough record that can be measured according to the methods deemed rigorous to science. Yet, decision and policy timeframes are more immediate – 10 to 20 years at the longest. Many policies and policy-makers have a finite time in office with the ability to directly influence or craft decisions. Furthermore, there is also considerable research (Marx et al. 2008; Barsky et al. 2002, for example) that demonstrates that people tend to discount the importance or impacts of future events, especially the further out those events might happen, relative to more near-term issues. Yet, the near-term policy focus can be in contradiction to the consequential nature of the long-term impacts that may far exceed the near-term, which is why mitigation efforts over the next 5-10 years will be so crucial. With limited political time horizons and climate change impacts being discussed in terms of 70-80 years, it starts to become clearer why concerted action on climate change is hard to initiate, let alone sustain. At the same time, scientists and practitioners focused on adapting to climate change are being forced to acknowledge that political and economic realities likely imply that the actual effective lifetime/impact of an intervention project could be a lot shorter than desired.

With who, then, does the responsibility lie for understanding and using climate information? If climate scientists insist that their job is merely to produce the information, but do not take the time to understand how people are interpreting or using that information, they run the risk of having that information misinterpreted and misused.

Likewise, potential users who do not seek to educate themselves and connect with an information producer might not be making the best decisions. This lack of shared communication and shared responsibility for communication threatens the credibility of climate scientists (as when the Climate Research Unit at the University of East Anglia drew heat for poor communication during public requests for clarification of its products); can stall local to international policy debates - leading to a continued delay in meaningful mitigation action; and leads decision makers to choose maladaptive strategies or opt for delaying action. Overcoming these misconceptions and miscommunications will take time, as it involves gradually changing people's perceptions about how climate science and policy-making are done.

Top to Bottom: Frameworks for Adaptation and When to Use What Information

In the Second IPCC Assessment (Carter et al. 1995: 825), the following recommendations were made for approaching adaptation research:

> *A general framework for conducting a climate impacts and adaptation assessment contains seven steps:*
>
> - *Definition of the problem*
> - *Selection of the method*
> - *Testing the method*
> - *Selection of the scenarios*
> - *Assessment of biophysical and socioeconomic impacts*
> - *Assessment of autonomous adjustments*
> - *Evaluation of adaptation strategies.*
>
> *Definition of the problem includes identifying the specific goals of the assessment: the ecosystem(s), economic sectors(s), and geographical area(s) of interest; the time horizon(s) of the study; the data needs; and the wider context of the work. The selection of analytical method(s) depends upon the availability of resources, models, and data…Development of the scenarios requires, firstly, the projection of conditions expected to exist over the study period in the absence of climate change and, secondly, the projection of conditions associated with possible future changes in climate…*

The whole framework, and methodology recommended to conduct the assessments, was based on a top-down, linear approach that started with the assumption that the root problem was climate change and that the assessment should begin with the climate science and then scenarios of future climate hazards and impacts (Füssel 2007; Füssel and Klein 2006). This approach relies heavily on having access to current (and historical) climate conditions and future climate projections. However, it has become clear since the late-1990s that such an approach has limited application, and is ill-suited to deal with the messy complexity of local reality in which data do not exist, are difficult to access, or not what is expected for making certain types of decisions, especially in developing country contexts. Furthermore, because the impacts and the strategies or responses for dealing with those impacts are inherently local, the top-down climate science approach is not well suited for learning from or incorporating the bottom-up experiences of individuals and communities. Individuals and communities have different perspectives and experiences of their local climate and hazardscapes that are not yet accepted as scientifically credible or widely allowed to contribute to climate science efforts (Pennesi 2007).

The historical prescriptions of "successful" adaptation and resilience frameworks or methodologies (UNFCCC Secretariat and Stratus Consulting 2005; Lim and Nordstroem 2002; UNDP 2010) are now beginning to be tested.

When the IPCC, the UNFCCC and other organizations offered these frameworks and methodologies as ways of guiding research, implementation and funding priorities, there were very few true adaptation programs in existence that took research beyond investigating vulnerability, risk, and the identification and prioritization of adaptation options into actual implementation. Such programs are beginning to emerge now, allowing for the testing of these recommended frameworks. Preliminary experience indicates the need for strong, bottom-up approaches that start with assessments of current vulnerability and a critical examination of the opportunities, constraints, and experiences that guide adaptation behaviors. This bottom-up approach then needs to be meshed with the top-down climate science approach. However, the evidence base is still insufficient to determine fully what elements of adaptation frameworks work, why they work and the gaps. Beyond frameworks lie questions of how to actually determine if an intervention contributes to adaptation, builds capacity and how to monitor the intervention beyond the lifetime of the program. Furthermore, the collection of knowledge emerging from actual adaptation interventions has yet to be incorporated by integrated assessment models or climate models, because feedback between the communities and actual number of interventions is still limited.

The Political Beast – Local Mice to Global Elephants in the Room…

While there are frameworks and prescribed methods for building resilience to climate change, politics and culture greatly influence all aspects of climate adaptation and mitigation, including the production of climate projections. Climate science lies very close to the boundaries between science, policy and public discourse because of the far-reaching implications of climate change, mitigation and adaptation actions. Yet many scientists strongly maintain the illusion that the scientific method ensures objectivity, openness, scepticism, disinterestedness and distance from politics (Berkhout 2010; Averyt 2010).

While many in the adaptation and science communities know about the Conference of Parties (COP) negotiations (and the majority of those negotiations occur behind closed doors), few know that both the emission scenarios driving the climate models and the projections released through the IPCC processes are partially negotiated through policy processes (IPCC 2008). In fact, the new RCP scenarios that are being used to drive the models feeding into the IPCC 5th Assessment, as well as the decision to generate near-term (out to about 2035) projections, were developed in response to requests from the global policy community to make the science more useful to the policy process (Moss et al. 2007). The IPCC is at the boundary between science and public policy, specifically designed to inform and influence global, national and local policy discourses about mitigation and adaptation. With climate science being thrust into public policy and media spotlights, acrimonious debates have arisen about its autonomy and authority to make claims. The debate about the appropriate role of climate science in informing and influencing policy negotiations will continue for the foreseeable future.

National debates regarding the authority to produce, control and release legitimate weather and climate data echo the international discourses, but are also influenced by the growing commercialization of data. Meteorological departments are concerned with meeting the mandates of the national government and yet, are frequently underfunded. Because of this, they often charge for data, but the pricing schemes and the official data request processes are not all that transparent. Furthermore, national meteorological agencies must follow the mandates of their national governments. In many countries, either explicitly or implicitly, groups and decision-makers from local to national levels are required to use government-sanctioned projections or other climate data produced by the government-sanctioned met office. Yet, as more climate information, including projections, becomes available via the Internet, it becomes harder for governments to control what information is used to support policy. This issue of government-sanctioned information also has ramifications for adaptation interventions related to/ or reliant upon policy. While NGOs or other organizations might be aware of multiple projections, if these projections are not sanctioned by the national government, it then becomes very difficult to actually develop adaptation interventions that are robust against a wide range of possible climate futures.

Each of the misconceptions and issues discussed in this section have manifested in some form or another in the various city contexts of the Asian Cities Climate Change Resilience Network (ACCCRN). The next sections describe the various processes related to procuring, understanding and utilising climate information in an urban resilience initiative, and the challenges that have arisen.

Climate Information in ACCCRN

"Access to information is low because of translation – the concept is very difficult too. Not just about changing rainfall – it's about changing lifestyle, how cities grow – the point is not to look at what will happen to the weather, but rather what will happen to us. And that concept is difficult – the combination of the social, development, and climate"

– comment from an ACCCRN partner.

The Asian Cities Climate Change Resilience Network (ACCCRN), funded by the Rockefeller Foundation, aims to catalyze attention, funding, and action on building climate change resilience for poor and vulnerable people by creating robust models and methodologies for assessing and addressing risk through active engagement and analysis of various cities. ACCCRN is an urban climate resilience action program being piloted in 10 cities across Vietnam, India, Indonesia and Thailand. Through collaboration between outside experts, national partners, local governments, and other organizations, ACCCRN enables each partner city to confront the complexities of climate change and develop the local capacity to address their specific challenges.

Cities engaged in the ACCCRN process are learning to anticipate how their current vulnerabilities might be exacerbated and altered by climate change, identify urban populations most affected by changing conditions, and develop climate resilience strategies and actions to meet the most serious climate impacts. Program partners are committed to building urban climate resilience as a continual process, realizing that as the climate begins to change, their cities, as well as their climate response, will need to constantly evolve. ACCCRN is intended to build local capacity and ownership to ensure that resilience plans, strategies, and actions are sustainable and can advance after the formal program ends.

Observations – Hindsight is 20/20

Perceptions about partners' abilities to find, interpret, and utilize climate information in the various ACCCRN contexts is influenced by an individual's or organization's understanding of climate information and biases toward how it should be used. ACCCRN national and international partners were presented with a questionnaire designed to elicit their perceptions on: 1) the process by which climate information was utilized in each country and/or city context; 2) the evolution in their understanding of how climate information *should* versus *could* have been used at various points in the project; and 3) their recommendations for what they think should be done differently in accessing, interpreting, translating, communicating and using climate information at various stages of the adaptation process.

The discussion of how climate information has been used in ACCCRN begins with *perceptions* of the process and climate information as gleaned from the questionnaire responses. These perceptions are a reflection of and influenced how the processes evolved in each city context and in the overall project itself. The perceptions are followed by descriptions of the *processes* – the actual steps by which information was incorporated in each country context. I have tried to supplement the perceptions with my (and other ISET staff's) experiences of working with various partners, notes from the shared learning dialogues/workshops, and correspondence, such as emails or notes from conference calls. All the responses to the questionnaires are held in strictest confidence and sources of information are concealed. This is done to protect the honesty, integrity, and ability to continue to speak freely of those who felt able to respond to my inquiries. Only my opinions will be directly acknowledged in this paper.

The issue of the role and usage of climate information is a delicate subject for many partners in ACCCRN and indeed, can be a sensitive topic in many other programs. This sensitivity is a reflection of the differentiated access to and understanding of climate information, a diversity of perspectives on the appropriate role of information, and the debate to figure out what constitutes adaptation in action. It is also a function of the inevitable politicization of climate information and science.

ACCCRN – In the beginning...

When the Rockefeller Foundation (RF) began developing a program for building urban resilience to climate change, they utilized a consultant to assist in the selection of cities according to a ranking of vulnerability. The consultant employed MAGICC-SCENGEN[6], a statistical downscaling packaged software, to generate climate scenarios for 2030 and 2080 for approximately 50 cities in Asia. From MAGICC-SCENGEN, basic scenarios examining temperature (increasing or decreasing) and precipitation (drier or wetter) trends were developed for each of the cities. Additionally, the consultant examined current frequency, intensity, and tracks of cyclones and created some scenarios of how they might be altered under various climate scenarios. The cities were then ranked according to the magnitude of possible changes in temperature and precipitation according to the downscaling, with cities facing extremely large or relatively little change being struck from the list. All of this information was used to do a rapid characterisation of potential impacts to health and other sectors for each of the 50 cities. From this ranking process, and other criteria such as the expression of interest from city governments that were approached, the current ACCCRN cities were selected.

Almost universally, respondents to my questionnaire indicated that when they first engaged with the ACCCRN program, they expected city/location specific historical climate data and high resolution climate projections to be available, readily accessible and in a useable format for the vulnerability and risk assessments and shared learning dialogues. Climate information was therefore viewed in terms of a supporting role to adaptation research, and not necessarily being a primary research component of the adaptation process, as program partners (including RF) assumed this information to already exist. A few of the technical supporting partners, having previously worked in Asian contexts, did not expect location-specific data to be readily available, but did assume that national meteorological agencies and/or research universities would be willing to share what data did exist, with few bureaucratic barriers. All partners expressed the hope that the information would eventually be used to guide the policies and interventions that might arise in the program, but were unclear in the beginning as to the actual guidance process by which the information would be used. However, the actual types of information partners expected to be available and expectations about how they could use it, varied from partner to partner. Types of information initially desired - precipitation, temperature, sea level rise, hydrological data or tropical cyclone projections, among others – were based on the location of the city and preliminary understanding of potential, location-specific impacts.

When Phase 2 was initiated in January 2009, few partners (national or the international) knew much about global circulation models, climate projections, uncertainty, or about the critical ocean-atmosphere patterns that influence Asian climate. As a result, ISET prepared a general guidance manual – *General Climate Change Projections for South and Southeast Asia: ACCCRN Guidance Note* – that was distributed to partners at the 2nd ACCCRN Regional Partners Meeting at the beginning of May 2009, weeks before the Vietnamese and Indian partners were about to begin their vulnerability assessment work. ISET also made a presentation to partners at the meeting. However, the guidance manual and presentation were both prepared without any dialogue with partners, and there was minimal feedback from partners about what they learned from them or if they were useful to them in finding and interpreting climate data.

6 For more information, see http://www.cgd.ucar.edu/cas/wigley/magicc/

Soon after the 2nd Partners Meeting, Indian and Vietnamese partners moved ahead with the shared learning processes, including the Shared Learning Dialogues (SLDs) - the primary stakeholder engagement process in the ACCCRN project (see Working Paper 1 for a more detailed discussion of the SLD process) - and Vulnerability Assessments (VAs). This left little time for dialogue and clarification of partners' understanding and expectations of the available climate information before it was in turn presented again to city partners. As the SLDs and VAs progressed, it became apparent that there were still quite divergent capacities for accessing, understanding, and utilising climate information amongst project partners at all levels. National partners began to encounter difficulties in finding data they sought, determining what data was available, and were challenged in conveying the information to city partners in a meaningful manner that did not treat the projections as the factual futures. This, and confusion about other methodologies generally, such as the VAs or SLDs, necessitated a Methods Workshop in Boulder, Colorado during October 2009. The Methods Workshop sought to cover a broad suite of methods being employed for different project objectives over a short period of time, and not all national partners were able to attend. Those who did attend expressed a greater capacity for understanding, interpreting, and conveying climate information to city partners post-workshop.

Common Threads

While there are differences in how climate information was accessed, interpreted, and utilized in each of the ACCCRN cities, there are a number of common challenges and constraints shared by ACCCRN partners. These include:

1. Limited data – both historical and climate projections – for the ACCCRN cities or the surrounding areas.
2. Users' expectations (although slowly beginning to change) that climate projections are finished, packaged products that are self-explanatory and easily obtained.
3. Difficulty accessing the data within the timelines the partners desired for the Shared Learning Dialogues, stakeholder consultations and Vulnerability Assessments. Difficulty in accessing data is as much due to *lack of data* as it is to *bureaucratic hurdles* related to data request processes and politics around which datasets are officially sanctioned for release and use.
4. Difficulty in accessing data also lies with the fact that much of the data are available only through archives such as the WCRP CMIP3 multi-model database[7], IPCC Data Distribution Centre[8], or peer-reviewed journal articles. Much information is tailored to and remains the purview of the discrete climate science community.
5. Because there are no standardised, regional climate model runs[9], there are no consistent sets of climate projections run with the same emissions scenarios or for the same future time slices for any of the ACCCRN countries. Since climate projections between the countries are so different, no comparisons can be made between the projections.
6. Due to the difficulty in accessing climate data by program deadlines, the focus of the VAs shifted toward placing a heavy emphasis on investigating current vulnerability. Scenarios of future vulnerability and po-

7 https://esg.llnl.gov:8443/index.jsp

8 http://www.ipcc-data.org/

9 The CORDEX initiative, a collaborative effort between multiple research centres, is attempting to generate a coordinated set of high-resolution, RCM projections for all areas of the globe. However, this standardised set of projections will not be available for a few more years. More information about the CORDEX Initiative can be found at http://copes.ipsl.jussieu.fr/RCD_CORDEX.html

tential impacts were then constructed from the analysis of current vulnerability and what projection data were available. This has led to a stronger focus on how current vulnerabilities are likely to be exacerbated by climate change, and only minimal focus on how climate change might create new situations/vulnerabilities unrelated to current issues.

7. Furthermore, misunderstanding about how scientists define "climate change", possibly due to the language and translation barriers described earlier, has led to some city partners attempting to attribute a recent event, such as flooding, to climate change when in fact that event might actually be due to infrastructure and land-use patterns, or well within the bounds of historic variability.
8. No explanations from the climate information providers as to how the historical data and climate projections were produced or what assumptions, biases, and uncertainties are associated with the data when data were released to partners. Data were frequently released in the same file format as they would be given to fellow climate scientists, not in a format easily interpreted by non-scientists.
9. Confusion amongst project partners about the difference between climate projections and climate impacts. Many partners expressed the desire to know how climate change might impact their cities, and expected climate scientists to be able to provide the localised impact data, without realising that while impacts research builds off of climate model research, the two are separate. Climatologists working on GCMs, RCMs and with statistical downscaling do not have the time or expertise to do climate impacts modelling; they produce projections of future climate based on various scenarios. Climate impact scientists have separate, integrated impact assessment models to examine climate impacts for a region based on climate projections. The two modelling communities interact and support each other's research, but do different work and produce different products.
10. No clearly articulated expectations at program inception between international and national-level partners as to who bore primary responsibility for collecting historical climate data and climate projections. In some instances, international partners were better placed to access certain types of data; in others, national partners were more easily able to collect historical climate data because of in-country bureaucratic processes.
11. Varying levels of experience/capacity and expectations amongst partners, and even more limited experience/capacity and expectations on the part of city partners, to interpret, understand, and utilize historical climate information and climate projections in adaptation work. This led to a few instances of over-interpreting data and higher levels of confidence in the data than were warranted. These situations challenged the ability of the technical supporting partners to unravel and diplomatically educate and support national partners in climate information gathering and usage. The capacity of partners has grown throughout the course of the program.
12. Communication between partners about the processes involved in accessing and utilizing climate information in various contexts has been limited, frequently because of the language and translation challenges. Few partners actually know much about each other's processes or challenges.

The nuances in perceptions and processes as they occurred in each country context, and in some instances, in different cities within the same country, are discussed in greater detail in the next sections. Each country section opens with a description of the agencies and research entities in that country with primacy for monitoring, collecting and disseminating historical climate data and is engaged in climate science research.

India

Bureaucratic and administrative barriers can play a significant role in limiting access to information, especially in the timeframe needed by partners. While there are extensive systems in place for collecting climate data in India (barring northeast states such as Uttar Pradesh and Bihar), the data is spread out across different agencies. In India, the bureaucratic challenges surrounding data acquisition manifest through there being 4 different sources of official data – the Indian Meteorological Department (IMD), the Indian Institute of Tropical Meteorology (IITM-Pune), the Central Water Commission (CWC) and the National Centre for Medium Range Weather Forecast (NCMRWF). The IMD, NCMRWF and IITM-Pune are situated within the Ministry of Earth Sciences, yet have different mandates and sometimes competing research foci. The CWC monitors river flows and issues water level and inflow forecasts for operation of some major reservoirs principally in flood prone states. It focuses heavily on flood forecasting and warning. Information on this is transmitted to relevant state-level authorities and other agencies connected with flood protection and management using telephones, special messengers, telegrams, and wireless. How it is transmitted in any given circumstance depends on the flood situation and existing communication facilities. IMD is the premier weather forecasting institution in the country. It monitors weather conditions and provides current information targeted to weather sensitive sectors such as agriculture and irrigation and to the general public, including 48-hours weather forecasts through Farmers Weather Bulletins and the Agrometeorological Advisory Service in consultation with agriculture experts working in state agriculture departments. It also produces longer-term crop weather calendars. More generally, the IMD plays a significant role in projecting and providing early warning for severe weather phenomena such as tropical cyclones, heavy rains, cold and heat waves. In comparison to the IMD, the NCMRWF has a more limited and targeted focus. It provides medium range weather forecasts using deterministic methods and also supports the Agro Advisory Service for farmers, yet has its own set of weather stations. Finally, the IITM functions as a national centre for basic and applied research in monsoon meteorology of the tropics in general, with special reference to monsoon meteorology of India and the surrounding regions. When it comes to developing climate projections for India, both IITM and IMD are in various stages of running RCMs.

Each of the above agencies has different systems for collecting, reporting, archiving, cleaning and disseminating data. For the IMD, weather stations are operated by the local IMD offices, which are in charge of monitoring the station instrumentation and collecting and transcribing data for stations that are not automated. The local IMD office reports the data collected to the state-level IMD office, which then reports the data to the national office in New Delhi. The variations in data collection makes it difficult for those requesting information to know who might have that information, how it was collected/generated and the sources of uncertainty/assumptions surrounding each dataset. The data request process is different for each agency, depends on who is requesting the information (international organization or in-country organization) and can be quite lengthy, often requiring personal visits to agency offices. These processes make it difficult for project partners or others to access potentially relevant information in a timely manner. Furthermore, the datasets themselves are not inexpensive, which although not a barrier to ACC-CRN partners is a challenge to organizations involved in adaptation work that have not budgeted for datasets and are unaware of costs.

Perceptions

National partners and international partners engaged in India expressed several issues when trying to conduct VAs, SLDs and in assisting the cities in crafting resilience strategies:

1. It is challenging to communicate to local partners what uncertainty is, its implications and the issues surrounding data quality, micro-climate processes and recent variability. Local partners have difficulty in understanding historical data and projection limitations, and did not know how to tailor interventions that were robust to a range of climate futures.

2. City partners initially had difficulty in accepting that climate change could have implications for their cities in the absence of city-specific climate projections.
3. The current climate hazards that the cities face shape city partners views toward future climate hazard risk. For instance, in Indore, water scarcity is currently a pressing concern. The limited climate projections available for the city indicate that annual rainfall might increase, although possibly through extreme rainfall events that could exacerbate waterlogging issues. Because water scarcity is such an issue, city partners expressed excitement over the possibility of increased rainfall and ignored the issue of extreme climate events or the potential impacts of such events.
4. National partners would like to explore other ways of communicating climate information, especially in trying to relate the information to potential impacts on daily life, micro and macro-impacts, and the ability to plan and strategise. Visual tools, such as the maps displayed in Figure 1, are quite helpful in displaying possible changes to precipitation and temperature. However, it is very difficult to portray uncertainty and the ranges and overall trends for a region with only 1-2 maps. Multiple maps are needed to portray ranges, yet can be confusing to city partners.
5. Checking the authenticity of data and the credibility of the source can be difficult, especially as climate information products become more widely available online, but are often presented without adequate explanations. Furthermore, there can be discrepancies even between official datasets generated at the local agency office versus those held by the national office, making it difficult to know which datasets should be utilized.

Process

In India, national partners took the responsibility of researching climate information and contacting the various meteorological agencies. Due to the ACCCRN structure, TARU engaged with Surat and Indore city partners, and Gorakhpur Environmental Action Group (GEAG) engaged with city partners in Gorakhpur, with ISET supporting both organizations. The processes by which national partners sought and incorporated climate information into the VAs, stakeholder consultations and City Resilience Strategies reflects: partner expertise. For instance, TARU has considerable expertise in rapid vulnerability assessment and spatial vulnerability mapping techniques, while GEAG is heavily invested in community/participatory research techniques. It also reflects prior experience with climate information and understandings of uncertainty; expectations for data usage; and the national election processes in 2009.

When national partners began with their rapid vulnerability appraisals in the 3 cities in March-April 2009, they were uncertain as to what data (climate, hazard, demographic, etc.) would actually exist for the cities or who would have that data. Furthermore, as the first phase of the rapid assessment involved semi-structured interviews with slum dwellers, partners chose to focus on perceptions and experiences of historical and current hazards in order to build profiles of current vulnerability. Researchers did not attempt to introduce concepts of climate change, historical climate data, or projections of future climate to the interviewees; and thus, had not collected any climate data prior to the start of the VAs. Stakeholder consultations with key individuals within the Municipal Corporations, and other key city agencies, were also initiated during this time. National partners relied on individual interviews and consultations with small groups (e.g. 2-3 individuals) to build current vulnerability profiles and gather data - refer to ISET Working Papers 1 and 3 of this series for more detail. Indian stakeholders and partners initially did not engage large, mixed focus groups in a dialogue and discussion of vulnerabilities and climate change as happened in Vietnam.

Secondary data collection of official datasets related to demographics, historical climate data, hydrological data, etc. was conducted in parallel to the semi-structured interview process. Partners approached agencies that they thought might have data, although they were not sure what they would be able to access. At the start of the secondary data collection, partners were more concerned with assets and exposure information, and information related the magnitude and extent of previous climate hazards. Historical climate data was collected from a variety of sources, depending on the city, in order to assess regional historical variability and for hazards assessments.

Gorakhpur:

In Gorakhpur and the surrounding area, historical rainfall, temperature and flood data are collected by 4 different agencies: the local IMD office, the Agricultural Department, the local Revenue Department, and the Panchayats Office. GEAG, in collaboration with ISET under a previous project (Risk to Resilience – RtR)[10], had access to historical climate data and statistically downscaled precipitation projections (run from 2010-2050) based on a single GCM (methodology available in Opitz-Stapleton and Gangopadhyay 2010). GEAG was able to utilize this data in preliminary vulnerability assessments and for initial flooding and waterlogging estimates for the city, which were presented to the City Advisory Group, Steering Committee and to all ACCCRN partners at the 2nd Regional Partners Meeting in September 2009. ACCCRN partners questioned GEAG's results, as presented, because GEAG did not present any climate projections, only current vulnerability profiles.

From the RtR project, both partners knew that historical climate data for Gorakhpur is limited, with considerable amounts of missing data. Furthermore, as the projections were based on a single GCM and two emissions scenarios (A2 and B1), the range of the projections was limited and GEAG required additional projections. GEAG contact the local IMD office in an attempt to supplement existing datasets, while ISET contacted the national IMD office for additional data. The local IMD supplied rainfall data for 1995-2008 and temperature data for 1991-2007. ISET obtained district-wise and 1°x 1° daily gridded rainfall data for 1901-2004 from the national IMD office. In doing so, partners discovered that the two IMD historical rainfall datasets (national versus local) did not match, even though they are ostensibly from the same station. The local IMD office attributed the discrepancies to manual data collection and entry before sending files to the national office, although Gorakhpur recently acquired an automated system. For many meteorological agencies, data cleaning and quality control occur at national offices, not at the local offices, leading to data discrepancies about which organizations requesting information may not be aware. After comparison of the historical data, GEAG and ISET opted to use the

Projection Data Used in Gorakhpur:

Temperature:

- **CSAG: SRESA2 Experiment (2046-2065):**
  - o CGCM3
  - o CSIRO
  - o CNRM
  - o MIUB
  - o MPI – ECHAM5

Precipitation:

- **ISET: Risk to Resilience Project**
  - o CGCM3:
    - SRES A2: 2010-2050
    - SRES B2: 2010-2050
- **CSAG: SRES A2 (2046-2065):**
  - o CGCM3
  - o CNRM
  - o MPI – ECHAM5

10 The Risk To Resilience Project was a disaster risk reduction and climate adaptation project carried out by ISET, GEAG and other partners in field sites in Nepal, Pakistan and India from 2006-2006 with funding from the ProVention Consortium, DfID, and NOAA. The costs and benefits of various flood and drought intervention packages were investigated for the Rohini River Basin, which encompasses Gorakhpur. More information on the analysis can be found at: www.climate-transitions.org or under the publications tab on ISET's website: www.i-s-e-t.org

national IMD data files, supplementing missing data with data from the Global Historical Climatology Network (GHCN)[11] and Climatic Research Unit[12] (CRU) archives.

GEAG requested additional climate projections in January 2010 from ISET to provide a more comprehensive range of possible future temperature and rainfall to city stakeholders and to inform the city resilience processes. Given time constraints, ISET was unable to generate additional projections via statistical downscaling and instead, sought projections from other climate research centres. Through contacts at the Stockholm Environment Institute (SEI), ISET was aware that SEI and the Climate Systems Analysis Group (CSAG) at the University of Cape Town had been collaborating to develop a software tool – the Climate Change Explorer Tool[13] – to provide statistically downscaled projections from a variety of GCMs for Asia and Africa. While CCE is still in the development and testing phases, projections downscaled from 8 GCMs (each utilized in the most recent IPCC assessment) are available for many of the ACCCRN cities. ISET procured the projections and analyzed the data for GEAG. In the process, ISET discovered that CSAG had made public the wrong datasets and informed CSAG in February 2010; CSAG re-ran their models and released new projections in March 2010. Once in possession of corrected data, ISET produced a report for GEAG in May 2010, *Simple Climate Scenarios for Gorakhpur* (Opitz-Stapleton 2010), which detailed the analysis steps and explained the data limitations before ISET released both historical and climate projection data. Additionally, TARU was able to procure climate projections (generated using the RCM PRECIS for the SRES A2, B2 and A1B scenarios) from IITM-Pune for Gorakhpur in late May 2010 that they shared with ISET. These have not yet been analyzed, nor has ISET completed an extreme events analysis data for GEAG using either the CSAG or PRECIS projection data, although it is hoped this analysis can be completed in the next phase of the program.

Indore and Surat:

TARU, with technical assistance from ISET, began seeking climate information around April 2009. TARU's expertise lies in GIS-enabled vulnerability mapping, which was employed during the VA and stakeholder consultation process in each city. TARU collected historical, daily precipitation and temperature data from the IMD and Anand Agricultural University in Gujarat, with the intent to analyze the data to examine historical variability, trends and recent changes in annual and monthly statistics. The analysis of the historical station data was designed to support analysis related to flood hazards and waterlogging mapping in both cities, as these are currently the phenomena of greatest concern. Additionally, Indore faces issues of local water scarcity and energy fluctuations due to the necessity of pumping water nearly 70 km from the Narmada River. Data were acquired through various protocols, involving telephone calls to confirm data existence, individual meetings and filling of forms/official letters to the agencies. All of the datasets were accompanied by metadata files explaining how to read the datasets, but lacked any explanations of data limitations or recommendations on data interpretation.

TARU's strength in GIS-assisted vulnerability assessments led them to seek climate projection data available in raster data format to be used in GIS applications, to develop future climate vulnerability maps. This search led them initially to utilize projection data from WorldClim, a database of interpolated, high resolution spatial data lay-

11 http://www.ncdc.noaa.gov/ghcnm/

12 http://www.cru.uea.ac.uk/cru/data/hrg.htm

13 The downscaling technique employed by CSAG is described in Hewitson and Crane (2006). The technique, as with all statistical downscaling techniques, relies on historical datasets that must be quality controlled. The CCE is still in a test phase and CSAG is hoping for widespread feedback to understand how users are perceiving, interpreting and using the tool in order to improve it. The tool is available through: http://data.csag.uct.ac.za/ and http://wikiadapt.org/index.php?title=The_Climate_Change_Explorer_Tool

ers of bioclimatic data for use in ecological modelling. WorldClim has collated observed climate data from a number of sources and generated global-extent GIS layers of 1km x 1km resolution for 1950-2000. However, some of the data, notably precipitation, have some errors and should be avoided. Furthermore the climate projection map layers available from WorldClim are from the IPCC Third Assessment (2001), and outdated for many parts of Asia. TARU presented projections from a single GCM, as downloaded from WorldClim, to ACCCRN partners at the 2nd Regional Partners Meeting in September 2009. Partners expressed concerns over the projections and data sources, noting that the maps displayed did not contain any information about potential ranges of change in precipitation or temperature or provide the historical data context against which to measure the projections. Due to these concerns, TARU sought assistance from ISET in finding alternative sources for climate projections, analysis, and in displaying data in a manner that could convey uncertainty and ranges to city stakeholders.

ISET directed TARU to the CSAG datasets and assisted in the selection of downscaled projections from those models that were best able to replicate the timing of key seasonal climate features, such as the monsoon season, for Indore and Surat. Additionally, TARU requested RCM projections from IITM-Pune, which unfortunately took approximately six months to acquire. The delay was largely due to the fact that IITM-Pune had not completed all of the model runs at the time of TARU's data request.

Projection Data Used in Surat and Indore

Temperature and Precipitation:

- CGCM3
- CNRM
- MPI
- GFDL
- PRECIS (driven by HadAM3P) for the following emissions scenarios A1B, A2, B2

In summary, even though India engaged early in the ACCCRN process, national partners found it difficult to access climate information, especially projections from reliable sources, in a timely manner that could support the VA, stakeholder consultation, SLD and city resilience processes. Multiple agencies with overlapping data collection mandates, multiple agencies at various governmental levels holding differing copies of what should be identical datasets, and overcommitted agencies scrambling to produce high quality, high resolution data all hindered the data collection and analysis process, which in turn impacted ACCCRN engagement.

Indonesia

The Indonesian Meteorological, Climatological and Geophysical Agency (BMKG) a national government agency, is in charge of administering and maintaining a network of weather stations throughout the country. The local-level BMKG offices collect and hold the station data, and ACCCRN national partners applied to the local offices for historical data. BMKG also houses the Tropical Cyclone Warning Center of Jakarta, which shares responsibility with Australian meteorological agencies for monitoring tropical cyclone formation in a portion of the Indo-Australian ocean region. The agency has conducted some regional climate downscaling work and has recently announced that it will begin monitoring GHG emission levels at various sites throughout the country.

Perceptions

The challenges faced by Indonesian national partners in acquiring, interpreting and translating climate information in a meaningful manner for city partners are similar to those experienced in the other ACCCRN countries. ACCCRN partners shared the following perceptions about using climate information in the various Indonesian contexts:

1. Information related to current climate hazards, as presented by climate scientists in the VAs does not match local partner's observations and needs to be verified. Indonesian partners are attempting to reconcile

datasets provided by the BMKG and by city meteorological agencies with city partners' knowledge on current hazard exposure.

2. Historical climate datasets are often incomplete, making analysis of historical variability and extreme events difficult.

3. Local partners also expressed concerns that the information is "too scientific", difficult to understand and difficult to translate into understandable impacts/implications that can be then used in the City Resilience Strategies. Partners are not currently sure how to use the available information – in its current format – in development and long-term planning.

4. Local partners are under the impression that climate change can only happen as a gradual process. They do not understand how impact risk – deduced from climate projections – can increase so rapidly between 2025 and 2050 as described by CCROM. Additionally, city partners have had just enough exposure to the IPCC assessment reports to be confused about emissions scenarios and how climate risk can be high even though a GCM has been run with a low emission scenario.

5. Partners have had difficulty accessing the local-level projection data desired for the City Resilience Strategies, especially projection data related to sea level rise and temperature data, simply because these data do not exist for the Indonesia cities. National partners had to downscale coarse resolution projections from GCMs to the city-level scale.

Process

Indonesia joined the ACCCRN program roughly six months later than India and Vietnam. As a result, the VA and SLD work did not begin until late 2009. Indonesian partners (CCROM, Mercy Corps and URDI) conducted three levels of assessment: a citywide vulnerability analysis (CCROM), a community-based assessment in sub-district identified through SLDs as vulnerable (Mercy Corps) and an assessment of governance in relation to climate adaptation (URDI). Results of these three reports were combined approximately 5 months later into synthesis assessment documents for each city. The synthesis documents begin with assessments of current vulnerability and capacity in the cities of Semarang and Bandar Lampung down to the *Kelurahan* or sub-district administrative level. Scenarios of future vulnerability, capacity and climate variability were extrapolated from a variety of information sources and from the current vulnerability and capacity profiles.

The climate assessment work was largely conducted by CCROM, who first began requesting historical climate data – rainfall, temperature and sea level - for the cities in October 2009. CCROM intended to use the data for assessing historical climate variability, extreme events and in the VAs. They first enlisted the aid of city-level partners (a university in Bandar Lampung and a local NGO in Semarang) in acquiring the data from the local BMKG offices. Unfortunately, only rainfall data were available, and these datasets were not as complete or as long a record as national partners hoped. CCROM supplemented the station data, with interpolated rainfall datasets available through the CRU database, in order to spatially and temporally disaggregate rainfall trends for the cities from 1901-2002. Station-wise temperature data were not accessible; therefore, CCROM used CRU temperature datasets to examine temperature trends through the late 20th century. Due to the patchiness of the historical rainfall data, and the mismatch in scale resolution between the CRU datasets and station data, CCROM used RegCM3 to generate high resolution rainfall data from 1958-2001. This simulated historic rainfall dataset was corrected for bias against the actual station data/CRU rainfall datasets in order to find a scaling factor to apply to climate projections.

Climate projection data was not available through the local BMKG offices. Instead, CCROM relied on projections provided by the National Institute for Environmental Studies Japan (NIES, Masutomi 2009). NIES extracted projections derived from 14 GCMs under the SRES emissions scenarios A2 and B2. CCROM rescaled the GCM projections to the city level using the scaling factor described above, which is a fairly common technique. In this manner, CCROM generated projections for 2 future timeslices for the cities: 2021-2030 and 2051-2060. The near-term timeslices were selected because they were deemed more relevant to city planning processes than end of 21st century projections. These projections were then used to evaluate how the frequency of extreme events might be altered by climate change, and to generate maps to display changes in general trends and ranges of temperature and rainfall to city partners.

GCMs Downscaled for Bandar Lampung and Semerang:

- bccr_bcm2_0,
- cccma_cgcm3_1,
- cnrm_cm3,
- gfdl_cm2_0,
- gfdl_cm2_1,
- giss_model_e_r,
- inmcm3_0,
- ipsl_cm4,
- miroc3_2_medres,
- miub_echo_g,
- mpi_echam5,
- mri_cgcm2_3_2a,
- ukmo_hadcm3
- ukmo_hadgem1

Climate information was presented to city partners through the SLDs, which were also used to discuss and verify the results of the VAs. During SLD1 in August 2009, participants were divided into three groups to discuss issues related to climate change that they thought might impact the cities. The first SLD was attended by two climate scientists from the National Council of Climate Change and by Dr. Rizaldi Boer of CCROM. Impressions and experiences with current hazards were used to focus the scope of the upcoming VAs. Between SLD1 and SLD2, CCROM, Mercy Corps and URDI conducted the VA in each city. As part of this analysis, a coping capacity index based on vulnerability and adaptive capacity and a composite of climate hazard index were overlaid onto a map to rank the cities' sub-districts by vulnerability. The vulnerability maps, indices and climate change projections were presented to participants at SLD2 in February 2010. Semarang expressed some scepticism with the vulnerability maps, noting that some sub-districts marked as currently vulnerable to a type of climate hazard did not actually experience those hazards. Additionally, in one SLD in Bandar Lampung, a participant from the local BMKG office questioned the historic rainfall datasets that CCROM used, yet CCROM noted that the datasets in question were provided by the local BMKG office and that they had no way of checking for discrepancies in datasets. City partners found it difficult to understand the climate projections and how climate risk could increase so rapidly between the earlier projection period and the later projection period. Both of these city stakeholder impressions indicate the need for greater education and capacity building in order to understand how climate projections and climate impacts are generated.

Mercy Corps, URDI and CCROM met to discuss the differences in interpretations of vulnerability. Currently, city partners in Bandar Lampung are working to reassess controversial elements of the vulnerability assessment in advance of drafting a City Resilience Strategy, while the Semarang working group is selectively incorporating data into its emerging strategy. Working Paper 3 in this series describes in greater detail the vulnerability assessment and resilience strategy preparation process in Indonesia.

Overall, in Indonesia, the main obstacle to incorporating climate analysis into the ACCCRN work was due to disagreements over the validity of datasets. This is in contrast to India, where the limitation was primarily of winnowing through a broad field of available data to obtain the most reliable data sets. However, both countries experienced challenges with partner (both city and national) interpretation of the available data, though in Indonesia the emphasis was on paralysis due to perceived inability to understand data in a highly technical format. In India, it was on misinterpretation of implications (i.e. Indore's focus on increased average annual rainfall rather than on rainfall variability) by city partners that challenged national partners ability to communicate data.

Thailand

The Thai Meteorological Department (TMD) under the Ministry of Information and Communication Technology is the key agency within Thailand that has borne responsibility for the collection and dissemination of historical climate data since 1923 (TMD 2010). In addition to this role, TMD provides a number of other functions including: short-term and seasonal forecasts for a variety of users (e.g. industry, agriculture and tourism), monsoon forecasts and the monitoring of tropical cyclones. TMD's mandate extends to disaster monitoring (climate hazards as well as earthquake and tsunami) and early warning for the country.

The Southeast Asia START Regional Center (SEA START) is the research node of the Global Change SysTem for Analysis, Research and Training (START) network in charge of conducting climate change research for Southeast Asia. SEA START's primary research focus is statistical and numerical climate projections for the region, accomplished via operation of a pair of RCMs - PRECIS and CCMA. The centre collaborates with meteorological agencies and academic research institutions in multiple countries, and provides services to the Mekong River Commission.

Perceptions

Thailand joined ACCCRN much later than India and Vietnam, in November 2009. As a result, project partners are still in the process of finalising the VA and SLD phases of the work at the time of writing (October 2010). Perceptions about the role of climate information in the Thai urban resilience processes reflect the difficulties and experiences encountered, and do not yet reflect attempts to incorporate information into the city resilience strategies. Common observations include:

1. It is difficult to identify the types of climate information – e.g. which timescales and for which variables – are necessary for vulnerability and impacts assessment, and urban resilience planning. Because partners were initially unaware of what types of climate products existed, it was challenging to know what data to request.
2. Partners still have some confusion about emission scenarios, such as A2 or B2, and climate models, often conflating the two. This confusion challenges attempts to understand uncertainty, projection ranges and the necessity of utilising projections from multiple models (if available) or being extremely cautious if results are available only from a single model.
3. City partners find it difficult to differentiate between the long-term impacts of climate change and the impacts of climate variability. Further linking of these to implications for economic development and urbanization are challenging.
4. Concepts of climate change are very strongly linked in city partners' view to existing environmental and ecosystem services problems, such as water supply shortages or flooding.
5. Thailand has had ongoing environmental awareness and climate mitigation campaigns, particularly at the city level, focusing energy saving, reduction of plastics, reforestation and recycling. Thinking in terms of additional climate vulnerabilities and the need to build resilience is not yet familiar to city partners.
6. Even when formal data request and bureaucratic processes are minimal, it can still take considerable time to acquire climate information from what has proved to be a chronically overwhelmed providing institute. Due to this delay, climate projections were not available to national and city partners prior to the start of the vulnerability assessments and shared learning processes. As a result, partners found it difficult to charac-

terize possible local climate impacts and implications.

7. Data interpretation and verification can be difficult and time consuming, as datasets are often provided without explanation or context. Partners found that some of the historical data are inconsistent, requiring further time consuming investigation to clarify data discrepancies.

Process

Because Thailand joined ACCCRN at a later date, TEI had the ability to communicate with other national partners and learn from their experiences in accessing and communicating climate information to city partners. Prior to the start of the SLD process in Hat Yai and Chiang Rai, TEI hosted Climate Workshops (early 2010) in each of the cities to ascertain the level of city partners' climate literacy. Thailand has promulgated multiple climate mitigation and environmental awareness campaigns for a number of years. However, the concept of climate adaptation is quite new. Through group discussions, TEI gauged partners' familiarity with i) understanding of the term climate change; ii) how climate change affects their livelihoods and communities; and iii) who are vulnerable to climate impacts and why. City partner responses indicated a low level of comprehension about climate change complexities and little scientific-language capacity. Part of the capacity to understand internationally promulgated climate science terminology and concepts is hindered by the Thai language, in which weather and climate are not really distinguished. Additionally, partners indicated that they have had little access to climate information and that their limited science background in this topic made the concepts confusing. The Climate Workshops provide TEI with a critical, initial knowledge and capacity assessment of city partners, before beginning the SLD or VA processes.

TEI introduced climate information to the city partners through the SLD processes. Based on the assessments from the Climate Workshop, TEI determined that city partners' climate literacy needed to be improved and sought to educate partners through the first SLD. During the first SLD in Hat Yai and Chiang Rai (February 2010), Dr. Anond Snidvongs of SEA START attended as a key speaker, presenting information on climate change and its significance to livelihoods and urban development at local, provincial and national scales. However, detailed city-level scenarios of future climate were only minimally addressed until the third SLD in each city, as the discussion of vulnerability focused primarily on current issues facing the cities and select communities in the urban areas. Furthermore, TEI was not able to access relevant historical climate data and future projections until after SLD1 or the beginning of the vulnerability assessments. During SLD3 (September-October 2010), TEI began to introduce climate projections to city partners and discuss them in terms of implications to vulnerable community groups and larger urban development processes.

TEI first requested precipitation and temperature data – both historical and projections - for Chiang Rai, the Kok River Basin, Klong U-Tapao Basin and Hat Yai in December 2009 from SEA START via email and a series of meetings between December 2009 and January 2010. Because of miscommunication, SEA START initially provided yearly modelled data – from the RCM PRECIS initialized with data from the GCM ECHAM4 - of average precipitation, T_{max} and T_{min} for 1980-2099 for two emissions scenarios A2 and B2 for Chiang Rai and Songkhla provinces. The yearly timestep of the modelled data allowed for description of broad changes in trends of rainfall and temperature, but did not allow TEI to explore possible changes in seasonal variation or extreme events. Furthermore, because data from only one model run with two emissions scenarios was provided, TEI had very little information on potential ranges of change magnitudes or variability.

As first provided, the information was not all that useful to TEI for their research and lacked the necessary level of detail for resilience planning. TEI then requested daily data, including sea level rise projections for Hat Yai, from SEA START. The use of climate data was further complicated by computer files being provided in file formats unknown to ACCCRN team members who were also given little guidance on the usage of data. When the partners were finally able to read the data files, they were warned that the data alone would not provide useful information without also considering the local context, such as hydrology, but that SEA START did not have enough location-specific data to provide the context. Later work with climate data showed its quality to be highly suspect, as precipitation data for Hat Yai indicated that the dry season received more rain than the wet season for historic data and the model reconstruction of the historical period. All data is now under review and all parties are working toward rectifying data issues.

Overall, the process in Thailand is not far enough along to offer clear comparison with the other three ACCCRN countries. However, it appears that data availability and interpretation will prove as challenging in Thailand as elsewhere.

Vietnam

The Vietnam Institute of Meteorology, Hydrology and Environment (IMHEN) under the Ministry of Natural Resources and Environment (MONRE), is the national agency with primacy for maintaining and collecting historical climate data and issuing climate projections. The national government tasked IMHEN with developing climate change scenarios for Vietnam by 2009 for issuing preliminary projections based on existing studies and statistical downscaling and by the end of 2010, issuing projections based on RCMs. Subsequent work will include updating these climate change scenarios every five years (MONRE 2009). IMHEN has also recently signed a memorandum of understanding with SEA START to collaborate on generating high resolution climate projections for Southeast Asia. A number of research organizations, such as Can Tho University, the Southern Institute of Water Resources (SIWRR) and the Institute for Water Resources and Environment (IWE), are engaged in various aspects of climate change research – from sea level rise and flood mapping projections to physical and social impacts work. Despite the existence of other organizations, IMHEN remains the only organization with the authority to develop climate projections that will influence national climate policy and adaptation planning.

Perceptions

Vietnamese partners pursued a different strategy to accessing climate information due to institutional arrangements within the country (see the Vietnamese "Process" section). Perceptions reflect the Vietnamese institutional arrangements and the early engagement of climate scientists in the urban resilience process:

1. Communication of uncertainty is difficult, as is communication of long-term climate change beyond the immediate horizons of concern for local partners. It is especially difficult to communicate this information at the grassroots level - to groups such as women's unions or fishermen's unions – or to policy makers, as different styles of communication seem to be required.
2. Historical data of sufficient length and quality is lacking in many parts of Vietnam, making it difficult to verify the robustness of the climate models in use, correct for biases in the projections, evaluate potential changes in extreme event frequency, duration or intensity or run hydrological models to examine future flood risk.
3. Trust in information sources and views over accuracy of data from different sources strongly influence the data people are willing to accept as credible and utilize in decision-making.
4. Despite the early engagement of climate scientists in the Vietnamese process, miscommunication and delays in accessing city-level datasets hampered some research efforts and caused frustration for project partners.

5. People may have some limited understanding of uncertainty, but some city partners sometimes express fright at what they perceive to be a "severe" scenario about which they feel they can do nothing. Some partners placed more emphasis on planning for scenarios in their "comfort zone" of capacity. Others sought "no-regrets" options that are robust against a variety of scenarios, including a move away from infrastructure projects, in an effort to address both uncertainty and their discomfort.

6. Cities incorporated climate projections into resilience strategies by acknowledging where climate change is likely to exacerbate current vulnerabilities related to droughts, storms, flooding and storm surges. However, there was relatively little exploration of new issues that could arise due to climate change – such as the impacts of extended high temperatures on infrastructure/energy grid or the economic impacts of losing one rice crop per year that would normally be exported.

Process

Given IMHEN's mandate, Vietnamese national partners engaged substantially with IMHEN from the initial Methodology Workshop in March 2009 and attempted to use IMHEN's products during the course of the VAs and the City Resilience Planning processes. Other physical science experts from universities and other research institutions participated in the initial and subsequent methodology workshops, some SLDs and assisted in the VAs. These other partners (Can Tho University, SIWRR and IWE) were contracted to provide city-specific assistance according to their expertise and previous level of engagement with other climate research initiatives in Vietnam.

At the first methods workshop, partners had not yet formalised their contracts, yet strongly felt the need to begin developing a shared understanding of methodology and research language. IMHEN had not yet completed city-specific projections, but gave partners an overview of climate research in Vietnam, including the policy process, and provided broad regional projections from existing research. SIWRR and Can Tho University (CTU) had been collaborating, with SEA START, on a World Bank funded project to investigate potential climate impacts for Can Tho. The two organizations were able to provide other partners with sea level rise and flooding scenarios for the city, with SIWRR providing spatial reference data on water height based on arbitrary SLR of 30, 50 and 100 cm (no dates), and CTU applied these to a DEM and GIS mapping system to derive flood depth info. The organisations also presented results of the impact assessment documenting how alterations to temperature and precipitation regimes could affect rice crops.

Partners finalised their contracts throughout March and April of 2009. IHMEN agreed to oversee the vulnerability assessments for the cities of Quy Nhon and Da Nang; including providing climate and sea level rise (SLR) projections under different emissions scenarios, some mapping of the direct flooding implications of SLR, and an overall review of the final assessment. IWE conducted the city-level VAs for Quy Nhon and Da Nang, including identification of current hazards, vulnerable groups and locations, and an assessment of future vulnerability using IMHEN projections. SIWRR was involved in some simple hydrologic modelling in Da Nang and Can Tho as part of the VAs, and more extensive modelling in Da Nang and Quy Nhon as part of water-sector specific detailed studies. CTU conducted the city-level vulnerability and impacts assessments for Can Tho. In all three cities, Challenge to Change (CTC) led community-level hazard and capacity assessments (HCVAs – refer to Working Paper 3 for more information) to ascertain the vulnerability of the most poor and marginalised populations in select wards of each city. NISTPASS provided overall project guidance and coordination, while ISET provided technical advice per partners' requests.

Between March and June 2009, IMHEN worked to generate city-specific projections using a combination of the statistical downscaling software MAGICC-SCENGEN 5.3 and rescaling techniques. The agency originally hoped to have high resolution projections available from PRECIS to partners by summer 2009. Lateral boundary conditions from ECHAM5 and HadAM3P (GCMs) would have been used to drive PRECIS, generating multiple projections and providing a broader range of possible climate futures than if only one GCM was used to drive the RCM. However, complications with model parameterization and initialization extended the length of the model runs and precluded using of these particular projections in the ACCCRN VA and SLD work. IMHEN has been working closely with the UK Hadley Centre to address these model complications and expects to have results available around the end of 2010 or the beginning of 2011 (personal communication with Dr. Van of IMHEN).

IMHEN ran MAGICC-SCENGEN with output from all 17 GCMs included in the package for the emissions scenarios A2, A1F and B2 for the following years: 2020, 2050, 2070, and 2100. For each emissions scenario and time period, the multi-model mean projection was retained for precipitation and temperature. All of the projections were produced on a monthly timestep, allowing for an assessment of potential changes in seasonal variation at each time period. Daily time-steps could not be run due to lack of historical data for each city, prohibiting assessment of changes in extreme events. IMHEN also analyzed 20th century sea level rise trends in tidal gauge stations and from satellite (TOPEX/Poseidon) data. SLR projections were generated using MAGICC-SCENGEN for the same emission scenarios and time periods as the temperature and precipitation projections. IMHEN created flooding scenarios for the three cities conditioned on the SLR projections, digital elevation maps of the cities, and current flood levels. These climate and SLR projections were not available to partners until the end of May 2009, after some of the vulnerability work had begun. However, this data was invaluable to the project. Prior to the IMHEN analysis undertaken for ACCCRN, little high resolution or downscaled projection data existed for any of Vietnam, and most of what did exist had not been produced by Vietnamese government agencies, limiting its use for official policy purposes. The IMHEN analysis provided the first relatively high-resolution, government, sanctioned dataset on which the ACCCRN cities could base their climate and vulnerability analyzes and resilience strategies.

However, due to the delay in availability of IMHEN's results, and in response to a request from CtC in April 2009 for simple, preliminary projections for Vietnam that could be used in the HCVA work, ISET wrote a general guidance manual – *General Climate Change Projections for South and Southeast Asia: ACCCRN Guidance Note* – that was distributed to partners at the 2nd ACCCRN Regional Meeting in early May.

National and some city-level partners reconvened for a 2nd Methodology Workshop in June of 2009 to discuss progress in the VAs, HCVAs and the projections released by project partners. It was at this 2nd workshop that the political complexities surrounding climate information, ownership and the ability to use particular sets of information in policy contexts came to the surface. Discussions at the meeting centred around the following:

- The flood map scenarios developed in accordance with the different emissions scenarios for different time periods only included the current city administrative boundaries. However, each of the cities has plans to annex surrounding areas and develop them. Future climate risk scenarios need to incorporate likely city development and growth plans to better account for risk and guide city partners in deciding what types of growth to allow and where.
- The SLR and flooding scenarios did not incorporate storm surge and high tide considerations. City partners expressed some scepticism about the future risk scenarios without the incorporation of these other factors.
- Partners highlighted the difficulty of collecting and reconciling hydrological and meteorological data for the cities from various official levels, from city to national agencies. It was noted that the simulations of fu-

ture flood risk, and to some degree the statistically downscaled climate projections, are very sensitive to differences in historical hydrological and meteorological data.

- Partners debated how to reconcile uncertainty in climate projections, especially for long-term time horizons such as 2050 or beyond, with the policy process in Vietnam. Local to national level planning is conducted on 5-year horizons, with many city forecasts and planning decisions and socioeconomic plans effectively limited to 2015 or 2020 at the longest. Without "officially approved" forecasts for key data (e.g. population, economic data, urban development) analysts felt that any estimates they generated locally would be subject to dispute and disregarded.

- IMHEN is the only agency authorized by the national government to produce climate projections that can be used in the National Target Program, Vietnam's climate policy program. However, several climate projections are available for specific cities from a variety of research studies or projects (e.g. World Bank for Can Tho, ADB for Ho Chi Minh city). These alternative projections provided different ranges of change in temperature and precipitation than those provided by IMHEN. Partners were uncertain how to reconcile the national mandate to use only IMHEN projections for official policy purposes when other projections exist that could enhance what is officially available. Partners also started to discuss how to handle other sources of climate projection data that are becoming available online, and what role these could play in Vietnamese climate policy. In Vietnam, all local plans must be approved by central agencies, and most of the parameters used for local planning (standards, projections, forecast data) are generated and sanctioned by national expert agencies within the relevant government ministry. *Vietnamese project partners are still negotiating the complex policy terrain dictating which sources of climate information are officially sanctioned and used to influence policy at the national and city level.*

There has been no further use of climate information since the final vulnerability assessments in the fall of 2009. Program emphasis in each of the cities has since been on vulnerabilities and on developing resilience interventions.

Unlike in India, Indonesia and Thailand, the Vietnam ACCCRN program was able to access some climate projection data for all three cities in a fairly timely fashion. The data is constrained to a small subset of available models due to national policy limitations. The ability to obtain data from a central national agency proved both advantageous and complicated. Perhaps because the data was limited in scope, or perhaps because it was delivered in a more "packaged" format (i.e. impacts to seasonal rice crops, hectares of land flooded, etc.) there seemed to be less confusion and concern on the part of the Vietnamese city partners in applying the results in their vulnerability and resilience analyzes. However, there was also little exploration of the potential for new climate-induced risks; analysis to date has been limited mainly to the potential for exacerbation of existing risks.

Perhaps more importantly, the involvement of climate information producers from project inception, while leading to some of the described conflicts, did allow for rich dialogue and an evolution in understanding and appreciation of the challenges of conducting urban adaptation work amongst partners, despite differences in backgrounds and research objectives.

Observations from Other Adaptation Initiatives

The issues being encountered in the ACCCRN program are not unique. They are echoed in many adaptation initiatives, whether those initiatives are in developing countries or developed countries.

- **The Risk To Resilience Program** (http://climate-transitions.org/climate, funded by DfID, NOAA, ProVention Consortium and IDRC) was an initiative explore the opportunities, constraints and policies guiding community disaster risk reduction and climate adaptation strategies in select field sites in Nepal, India and Pakistan. In particular, the program sought to identify and evaluate (in terms of their costs and benefits) pro-active disaster risk management strategies, including risk reduction and risk transfer. In addition to the language and conceptual differences about weather and climate between South Asian cultures and Western climate science, the program encountered difficulties in accessing quality data in a timely manner. Because some of the field sites were close to national borders, some of the national agencies refused to share climate and hydrological data, citing national security interests. In other field contexts, datasets were highly incomplete and contained physically impossible numbers, such as negative streamflow. Some stream "gauge" data were actually collected via observation of where water levels reached marks painted on bridge pilings; however, during floods when the bridges had been destroyed or were underwater, the hydrologist just estimated flood levels and these became the official record. In other instances, official daily historical climate datasets were provided in a tea shop by government officials who filled in 2+ years of daily temperature and rainfall data for 5 weather stations. These data issues, among others, challenged the ability of the researchers to conduct traditional, quantitative cost-benefit analysis and highlighted the importance of shared learning processes for overcoming information difficulties.
- **The Adapting to Climate Change in China Program** (ACCC - http://www.ccadaptation.org.cn/en/index.aspx), a collaborative effort between the Swiss, UK and Chinese governments, seeks to improve understanding of potential climate change impacts in 3 Chinese provinces: Guangdong, Ningxia and Inner Mongolia. Climate information, including high resolution projections, are being provided to the project partners by the China Meteorological Administration, Chinese Academy of Agricultural Sciences, Institute of Atmospheric Physics and the UK Met Office Hadley Centre. The four organizations began modelling efforts almost a year and a half before other partners began work on physical and social impact assessments and adaptation planning. Despite the advanced lead-time allotted for generating climate change scenarios and the heroic efforts of the climate organizations, the models are not yet complete. Other partners have had to begin their assessments without this information. Furthermore, while there was some dialogue between various project partners about meeting impact assessment and adaptation planning information needs and how to make the information useful, it remains to be seen as to whether project partners will be able to use the information when it becomes available. Each of the three (physical, social and climate science) research groups has minimal interaction with each other and there remain relatively few opportunities for coordination of research efforts.
- **The New York City Panel on Climate Change** (NPCC - www.nyc.gov/html/om/pdf/2009/NPCC_CRI.pdf), established with support from the Rockefeller Foundation, as part of an initiative by the city to develop climate change and impact scenarios, conduct risk assessments, develop and evaluate adaptation strategies and monitoring criteria that can help the city respond to the challenges of climate change. When the city initiated the process and began engaging with a variety of stakeholders, the workplan was structured around the assumption that scientists would develop climate projections and impacts for the city, which would then be given to other stakeholders who would use the reports to develop adaptation recom-

mendations and prioritize actions. Even though the U.S. is a climate data rich environment in comparison with many developing countries, it took the climate scientists approximately 1 year longer than planned to produce the requested information. The delay in developing projections and impact scenarios had both benefits and drawbacks to the project. Because of the delay, more dialogue occurred between the scientists and other stakeholders than had been envisioned and the scientists became stakeholders in the process. This allowed non-scientists to gain an appreciation of how climate models operate, their limitations and the necessity of considering uncertainty in urban resilience planning. Likewise, the scientists began to understand that different stakeholders had different information needs due to varying thresholds of concern - for example, energy utilities were concerned about different temperature thresholds than public health officials. The downsides to the information delays were that project costs increased significantly, as did the time requirements for most of the stakeholders who largely volunteered their time.

Each of the above examples highlights some of the various challenges that arise when trying to effectively incorporate climate information into adaptation and resilience planning initiatives. Other programs, both large and small, in developing or developed countries, face similar constraints. Despite these challenges, or perhaps because of them, individuals in the climate science and adaptation/development communities are beginning to recognize the need to change directions.

Directions for Effective Communication and Use of Climate Information

Relationships between the adaptation/development communities and climate science communities are still quite new and in exploratory phases. Understanding about each other's research methods, priorities and goals does not yet exist, for many of the reasons discussed earlier in this paper. A number of new directions are emerging, however, that signify the beginning of efforts to bridge climate science and adaptation science. Some of these directions are listed below:

Process-based Initiatives

- Increasing calls for dialogue between climate scientists and the adaptation community, particularly through the IPCC process
- Greater focus on shared learning through programs such as ACCCRN
- The inclusion of climate scientists as stakeholders (but not dominant stakeholders) that are engaged early in programs, leading to greater capacity building of all stakeholders such as in the New York City Panel on Climate Change
- Groups actively investigating better ways of communicating climate information, such as the Center for Research on Environmental Decisions (CRED) at Columbia University.

Science Initiatives

- A tacit acknowledgement by the Conference of Parties that climate projection data included in the next IPCC assessment needs to be more user friendly (although what this means is not defined) and respond to near-term policy perspectives, while continuing to investigate the potential longer-term climate change patterns and impacts.
- Dialogue that the extreme threshold analysis conducted by climate scientists needs to support the critical thresholds pertinent to health care providers, agriculture extensions, energy analysts, etc.
- Climate modelling initiatives (the Co-Ordinated Regional climate Downscaling Experiment – CORDEX initiative or efforts to make RCMs available to scientists in developing countries along with assistance to run the models) to produce higher resolution projections for all parts of the world.

Institutional Initiatives

- Growing recognition for the need for individuals and organizations that can serve as *information brokers* - individuals who understand the science behind climate information production and are engaged in adaptation research – that can bridge disciplines, foster dialogue and serve as an information translator
- In response to these calls, some universities are developing advanced multidisciplinary degree programs that require training in physical and social science research, some even in the context of climate adaptation or climate information communication
- Groups emerging among the climate science community calling for better communication efforts, while simultaneously attempting to educate themselves and engage in social science research methods, adaptation and disaster risk reduction. Such groups include the Weather and Society* Integrated Studies (WAS*IS) or the UK Climate Impacts Program (UKCIP)

Technological Initiatives

- Calls for a *international data repository* of historical and climate projection data that are available online for free or minimal charge through the World Meteorological Organization.
- An increase in the number of climate science articles that are now being published as open source, allowing for free access
- Joint initiatives between scientists, artists and adaptation experts to depict regional and local-scale climate projections or impact scenarios in multiple formats – from GIS layers and maps to audio documentaries and videos. Such initiatives include the new Google Earth climate layers, although such initiatives are still struggling to figure out ways of presenting uncertainty and projection ranges.

References

Finally, to close this paper, I offer a short criteria list for evaluating the growing number of websites offering climate information products, and links to a few select sites that meet most of the criteria. Web-based data portals are offering individuals around the globe, including in developing countries, unprecedented access to information and climate data. However, as with all that is online, some sources are completely unreliable or poorly inform potential users about data limitations. Adaptation and mitigation decisions partially based on poor or incomplete information face the high risk of being maladaptive and costly to rectify. Therefore, here is a short list of criteria to consider when evaluating a climate information website:

Criteria for selecting web-based climate information:

- Scientific concepts are presented clearly and in non-technical terms
- Climate impacts, if discussed, are related to experiences or situations that are relevant to particular user groups to make it meaningful. For example, this can include discussions about how projections indicate that the number of heat wave days (say temperature above 40°C) might increase between 10 and 50% when compared with the last decade and that companies should consider relaxing their dress-code on these days.
- Websites containing datasets educate potential users about:
    - Uncertainty
    - The necessity of using multiple projections from multiple models
    - Clearly describe the methods by which historical data were gathered and quality controlled or the method used to downscale the climate projection data.
    - Provide a cautionary note describing data limitations and what is NOT appropriate to do with the data.
    - Provide clear directions on how to download the data and read it
    - Provide the data in a common format that can be easily imported into Excel or as GIS-layers.
    - Projection data can be easily compared to a clearly defined historical reference period in order to demonstrate what the changes mean.
    - If possible, allow users to "play" with projections from multiple models, multiple emissions scenarios, and for multiple time periods to see uncertainty and how the climate responds differently depending on the scenario.

Some Good Websites (all accessed October 2010):

All of these websites are in English; I have not evaluated websites in other languages.

Climate Data Products:

- Climate change in Australia: http://www.climatechangeinaustralia.gov.au/index.php
- Climate Systems Analysis Group (CSAG) at the University of Cape Town - http://data.csag.uct.ac.za/

- India Water Portal - http://indiawaterportal.org/metdata
- Canadian Centre for Climate Modelling and Analysis - http://www.ec.gc.ca/ccmac-cccma/default.asp?lang= En&n=4A642EDE-1

Communicating Climate Information:

- Center for Research on Environmental Decisions (CRED) at Columbia University of New York City- http://www.cred.columbia.edu/guide/guide/sec1.html
- George Mason University: Center for Climate Change Communication - http://www.climatechangecommunication.org/

Climate Concepts

- UK Climate Impacts Program: http://www.ukcip.org.uk/ (main website)
  - Understanding climate change (thematic link under main site) - http://www.ukcip.org.uk/index.php?option=com_content&task=view&id=73&Itemid=186
  - Tools to help in adaptation and resilience planning (thematic link) - http://www.ukcip.org.uk/index.php?option=com_content&task=view&id=74&Itemid=187
- From Risk to Resilience: Responding to Climate Change and other Natural Hazards through Adaptive Risk Reduction (project website with detailed information and methods) - http://climate-transitions.org/climate/
- The Resilience Alliance - http://www.resalliance.org/1.php
- weADAPT - http://www.weadapt.org/

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