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CLIMATE CHANGE
AND AFRICAN
POLITICAL STABILITY

Mapping and Modeling
Climate Security Vulnerability:
Workshop Report

Edited by Joshua W. Busby and Jennifer M. Hazen
October 2011

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Program on Climate Change and African Political Stability

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Climate Change and African Political Stability Program

The Strauss Center's program on Climate Change and African Political Stability (CCAPS) seeks to better understand the relationship between the growing threat of climate change and the ability of African countries to manage complex emergencies, including humanitarian disasters and violent conflict. A collaborative research program among four institutions and led by the University of Texas at Austin, the CCAPS program aims to provide practical guidance for U.S. policymakers, enrich the current body of scholarly literature, and nurture a future generation of scholars and practitioners.

The CCAPS program is funded by the U.S. Department of Defense's Minerva Initiative, a university-based, social science research program focused on areas of strategic importance to national security policy. Through quantitative analysis, GIS mapping, case studies, and field interviews, the program seeks to identify whether climate change could trigger disasters that undermine state stability, to define strategies for building African state capacity, and to assess global development aid responses. The CCAPS team seeks to engage Africa policy communities in the United States, Africa, and elsewhere as a critical part of its research.

The CCAPS Program:

- **Investigates where and how climate change poses threats to stability in Africa.**
The program examines the spatial and temporal relationship between climate change vulnerability and patterns of conflict, thereby specifying where, when, and how climate-related events disrupt Africa's security and development. The program is producing new datasets mapping climate change vulnerability and cataloguing political and social disorder in Africa.
- **Identifies strategies needed to reinforce or rebuild accountable and effective governance in Africa, with a particular focus on constitutional order and post-conflict reconstruction.**
The program aims to assess what strategies have enabled governments to minimize the effects of climate change and other stresses on political stability. The program is conducting case studies on constitutional design and conflict management, assessing governance structures, and evaluating institutional capacity for complex emergencies in Africa.
- **Evaluates the capacity and effectiveness of international development aid to help African societies adapt to climate change.**
If effectively coordinated and implemented, aid for climate change adaptation should contribute to crisis prevention, risk reduction, and minimize the need for global assistance. The program's work is to build a dataset to track adaptation aid, analyze aid distribution, and assess effectiveness of adaptation projects.

Background to the Workshop

The CCAPS program held a workshop on May 16-17, 2011 to explore issues related to mapping and modeling climate vulnerability. Bringing together a range of experts from academic, government, policy, nongovernmental, and private sector institutions, the workshop sought to forge tighter ties among the community of experts in this area, identify best practices, think through research challenges, and inform public debate.

The workshop was convened under the Chatham House Rule. As such, participants are not identified in the report.

The report has been assembled based on pre-workshop submissions and workshop presentations of the participants. However, responsibility for the text in the report rests with the CCAPS program, and any errors should not be attributed to participants.

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Executive Summary

The overarching theme of this CCAPS workshop was defining, measuring, and modeling the concept of climate security vulnerability. Climate security vulnerability, for the purposes of this workshop, refers to the vulnerability of populations to extreme weather events, such as droughts or floods, resulting from changing climate. Unlike other approaches to vulnerability that focus on threats to livelihoods, the CCAPS approach has a distinct security focus. This means an emphasis by some CCAPS researchers on the risks that climate change will put large numbers of people at risk of death, potentially requiring military mobilization for humanitarian relief and other emergency responses to shocks that test state capacity. For other CCAPS researchers, the focus is on whether the effects of climate change will trigger conflict. CCAPS defines climate security vulnerability as a function of physical exposure as well as demographic, social, and political factors.

Largely using historical data, CCAPS created a composite index of climate security vulnerability based on four “baskets” of indicators: physical exposure, community and household resilience, governance and political violence, and population density. The results of the index analysis are used to produce maps of vulnerability at the subnational level to reflect which countries should be of concern as well as which locations within a given country. For the purposes of both analysis and response, it is not enough to say that Ethiopia, for example, is vulnerable to climate change. What is needed is the ability to indicate which parts of Ethiopia are vulnerable and why.

Several components of the CCAPS composite index – physical exposure, community and household resilience, and governance and political violence – provided the structure for the organization of the workshop. The workshop raised a number of questions about the CCAPS approach to vulnerability and the discussion centered on challenges to developing indicators, improving data quality, and addressing uncertainty.

Climate Hazard Mapping

Climate change is expected to generate and exacerbate a number of severe weather-related events resulting in natural disasters. A climate-related hazard is an event in the physical world that can plausibly be related to climate change. This includes drought, floods, cyclones, wildfires, and coastal inundation. Climate hazard modeling seeks to inform policymakers of the geophysical threats associated with climate change, and when and where they might occur, so that policymakers can better address the resulting human, socio-economic, and political threats.

Climate hazard maps aim to identify areas most vulnerable to a particular hazard. Mapping climate hazards has three broad goals: explaining past patterns of exposure; indicating potential consequences of climate change in the future; and, identifying potential hotspots of high stress in the short- to medium-term. Whether existing data and available indicators are sufficient to analyze historical climate hazards or prepare for future ones rests on the question being asked. A range of possible indicators of measuring drought exist, but only a few are good at measuring *past* climate hazards and hotspots. Few are especially good at anticipating *future* hotspots and hazards. At present, no combination of indicators can measure all three outcomes of interest: past shocks, future shocks, and hotspots.

Regional Climate Models

Existing global climate models have coarse resolution and therefore may introduce bias – systematic errors between the model data and observed results. Although scientists have employed a number of strategies to provide more regionally accurate climate models, challenges persist in using these models as the basis for policy decisions. Policymakers want near term projections of climate change. However, the problem of noise in the data – reflecting natural chaotic variability in the climate system – makes it difficult to distinguish the climate signal from natural variability, and more accurate projections may not be possible until later in the century. Policymakers also want precision and a clear indication of the appropriate response. However, climate models cannot produce a single right answer given the inherent uncertainty within existing models and data. Rather, confidence in projection must be derived from multi-model convergence and an indication of the probability of any given future projections. At best, scientists may be able to generate a number of different models and compare them to each other and to historic weather patterns in order to generate best estimates based on existing knowledge.

Social Sources of Vulnerability

Vulnerability is highly context specific. There is no common definition or conceptualization of the term. Yet it is widely accepted that vulnerability is more than simply exposure to a hazard and should include measures of social, economic, and political factors that affect the ability of individuals and communities to absorb the impacts of hazard events and respond to crises. The level of analysis also matters for assessing vulnerability, as does capturing the various competing interests of actors. Current analysis handles competing vulnerabilities poorly.

Responding to vulnerability is a highly political act. There will likely be an influx of adaptation aid for addressing vulnerability to climate hazards, but many questions remain as to how to allocate that aid effectively and fairly. Favoring effectiveness may lead to more funding going to those countries that can use it, rather than those who most need it. It is also important to understand that climate adaptation could require significant changes in current local and national practices.

Governance and Violence Mapping

Efforts to localize and study subnational vulnerability inevitably raise questions about the appropriate units of analysis. There are several options, including administrative units, grid squares, and ethnic groups. Who is deemed vulnerable has important implications for how governments respond. Decisions can be largely political, based on relevant power cleavages in society such as ethnicity, clan, or political party. This can lead to allocation based on political interests rather than need, thereby heightening the vulnerability of some, while reducing vulnerability for those with the right political connections. Over time politics often change, suggesting that vulnerabilities could also change based on who is in power in government and which groups can access support during times of crisis.

Vulnerability Index Mapping

Vulnerability is a measure of exposure, sensitivity, and adaptive capacity. These factors can be mapped at different levels of analysis. However, the level chosen for analysis can highlight or mask important differences. For example, global mapping of vulnerability can mask important regional differences, while local mapping can overemphasize minor differences. Assessing and mapping vulnerability can be difficult due to gaps in available data and questions over how to handle these. Researchers must be able to communicate their data results effectively and simply. Maps and indices should provide a clear presentation of research findings, while not overstating the case or allowing audiences to take away the wrong message. Confidence levels and error margins are difficult to display in maps, often resulting in a much more stark presentation of data than may be warranted. Maps often leave little room for nuance. Despite the challenges of creating and using maps, they can provide an important starting point for a dialogue between research and policy spheres, but maps on their own may provide insufficient guidance to policymakers. What is mapped largely depends on what is of interest (e.g. need, vulnerability, capacity) and this needs to be clear. Different audiences are likely to need different maps.

Significance of Mapping to Policy

An increasing number of government agencies have demonstrated an active interest in climate change. Although divergent views on the exact impacts of climate change remain, there is widespread recognition that climate change is likely to aggravate existing problems and add additional stressors to already fragile situations. Environmental factors are being considered for inclusion in early warning systems and assessments of state fragility. Policymakers agree that a major investment in data collection and the improvement of early warning systems is needed. Drawing from the academic community is important, but many point to the need for the government to develop an internal capacity to conduct ongoing research and analysis, as well as improving the information sharing practices across agencies. Integrating climate change in policy decisions requires understanding complex social interactions and incorporating information from both the natural and social sciences. Policymakers face the challenge of how to utilize research and analysis for developing sound policies and how to weight the cumulative uncertainty that results from the numerous, and potentially discordant, research inputs.

INTRODUCTION

The overarching theme of this CCAPS workshop was defining, measuring, and modeling the concept of climate security vulnerability. Climate security vulnerability, for the purposes of this workshop, refers to the vulnerability of populations to extreme weather events, such as droughts or floods, resulting from changing climate. There is no single accepted definition of vulnerability and the numerous ways of defining and measuring vulnerability are discussed throughout the report. This section introduces the approach taken by the CCAPS research team, which provided the basis for the workshop.

CCAPS defines climate security vulnerability as a function of physical exposure as well as demographic, social, and political factors. Physical exposure in CCAPS' vulnerability work reflects the historical frequency and severity of climate-related extreme weather events. Areas at high risk of exposure and large populations are likely to command more attention from decision-makers than scarcely populated regions. However, exposure alone does not determine the outcome of an extreme event. In the event of physical exposure, the first line of defense for many communities is the availability of local resources, such as education, health, and access to services. Communities exhibit different levels of resilience – the ability to cope with adversity – based on existing resources. In many cases the capacity of households and communities to cope will be exceeded by the gravity of the climate hazard. Governance – the willingness and ability of the government to aid communities in times of need – is therefore another critical component of vulnerability.

Largely using historical data, CCAPS research has created a composite index of climate security vulnerability based on four “baskets” of indicators: physical exposure, population density, community and household resilience, and governance and political violence. Only the population density index is based on a single indicator; the other baskets are based on multiple indicators. The four baskets are equally weighted in the index. The results of the index analysis are used to produce maps of vulnerability at the subnational level. This mapping reflects not only which countries should be of concern, but also which locations within a given country. In other words, for the purposes of both analysis and response, it is not enough to say that Ethiopia is vulnerable to climate change. What is needed is the ability to indicate which parts of Ethiopia are vulnerable and why. The research team has carried out sensitivity analysis to determine whether changing the weighting of the baskets generates significantly different maps of vulnerability. Results are largely robust across different model weight specifications.

The research team has developed a number of extensions from the original model. First, the team has partnered with climate scientists from the Jackson School of Geosciences at the University of Texas at Austin to develop regional climate models for Africa that focus on mid-term time horizons (2050). This time horizon is close enough to the present to be useful for decision-makers, but distant enough from the present to be rigorous from a scientific perspective. The team is comparing these mid-century projections to historic vulnerability to identify areas of overlap between areas of historic exposure to climate-related hazards and projected future exposure.

Beyond the work on climate projections, CCAPS has examined a number of other important dimensions likely to affect vulnerability. CCAPS has overlaid indicators of ethnic political exclusion on climate security vulnerability to see where populations that lack political representation are also vulnerable to climate change. Similarly, the team overlaid indicators of social conflict and terrorism on climate security vulnerability to see where they may be co-located. The current iteration of the CCAPS vulnerability model is not based on an econometric model because of data limitations, though an extension aims to assess the adequacy of the current model using statistical tests. In addition, another CCAPS research team is mapping foreign assistance projects to identify the locations of climate change adaptation-related aid projects. Overlaying the maps of vulnerability and adaptation aid could help to identify whether places receiving adaptation assistance are the ones where vulnerability is most concentrated.

The workshop discussion examined a number of issues around the CCAPS approach to vulnerability: Does a security emphasis on extreme weather events and the risk of mass death encompass the main elements of climate security vulnerability? How would vulnerability be defined if the “security” emphasis were omitted? Is the CCAPS methodology for aggregating indicators into a composite index an appropriate way to identify hotspots of concern?

The discussion also centered on problems of data quality and certainty. Mixing relatively accurate information with known unreliable information into single combined model introduces uncertainty in outputs from these models. Data collection can be difficult in Africa due to lack of existing data, lack of data collection mechanisms, and limited geographical coverage of existing collection mechanisms. For example, data collection of economic activity is known to be incomplete due to the significant role played by informal markets, the current high level of growth on the continent, and the lack of capacity to capture these in current collection efforts. The quality of data also differs by country and by region, with very uneven availability of subnational data. Many of the substantive and methodological issues highlighted during the workshop mirrored the challenges the CCAPS research teams previously identified while conducting their own research.

Several components of the CCAPS composite vulnerability index – physical exposure, community and household resilience, and governance and political violence – served as a template for structuring the workshop into six substantive sections. The first two sessions addressed physical exposure, both historical exposure to climate-related hazards (Session 1) and the likely future vulnerability to climate change as assessed by regional climate models (Session 2). Session 3 focused on the social sources of vulnerability and addressed research challenges in understanding household and community resilience. Session 4 addressed the importance of governance and political violence, examining the effects of both on climate security outcomes as well as the appropriate units of analysis for understanding climate security. Session 5 highlighted various composite vulnerability maps and sought to present different perspectives on integrative models of overall vulnerability. Session 6 took a step back from the focus on data and methodology to reflect on the implications of this research for policymakers and to identify what information would be useful for policymakers. The workshop closed with a discussion of next steps.

SESSION 1: CLIMATE HAZARD MAPPING

Session objectives: Mapping historical exposure to climate-related hazards is a critical part of determining an area's likely vulnerability to future climate change. Drought data for Africa in particular appear to be problematic in terms of mirroring areas known to be susceptible to drought. What are the appropriate indicators of historical climate hazard exposure? What are the best data sources to capture drought?

Climate Hazards and Mapping

A climate-related hazard is an event in the physical world that can plausibly be related to climate change. This includes drought, floods, cyclones, wildfires, and coastal inundation. Climate hazard maps aim to identify areas most vulnerable to a particular hazard. Climate hazards vary significantly across regions, and even across countries, requiring more fine-grained analysis than is currently available from global climate models. Regional and sub-regional models will be important advances in future research.

Mapping climate hazards has three broad goals:

- Explaining past patterns of exposure;
- Indicating potential consequences of climate change in the future; and
- Identifying potential hotspots of high stress in the short- to medium-term.

These goals require different approaches. Assessing past patterns of exposure requires integrating climate hazards into existing models measuring conflict and instability and using existing historical data. Past exposure can affect how people adapt to the negative effects of climate change, thus enabling them to respond more effectively to future hazards. When trying to assess how climate change might affect climate hazards and the resulting consequences in the future, models must rely on forecasting. This requires using climate projections, which remain inadequate, as well as known conflict drivers, which are inherently hard to predict (e.g. ethnic fractionalization, gross domestic product). In short, we care about the future but have data about the past, which makes it difficult to inform policy. Climate hazard modeling seeks to inform policymakers of the geophysical threats associated with climate change, and when and where they might occur, so that policymakers can better address the resulting human, socio-economic, and political threats.

Vulnerability Mapping of Drought

Climate change is expected to generate and exacerbate a number of severe weather-related events resulting in natural disasters. One notable example is rainfall levels; both an abundance leading to flooding and insufficient rainfall leading to drought. In sub-Saharan Africa shifting rainfall patterns are expected to alter not only crop production and food security, but also many common ways of life on the continent. Drought data is particularly problematic and therefore provides a useful example for exploring the challenges of climate hazard mapping.

One of the biggest challenges to identifying and responding to drought is that there is no common definition or conceptualization of drought. Drought is commonly identified as a situation in which the supply of water does not meet the demand. However, simply stating there is “a lack of water” is not enough to understand drought. Water availability and usage vary greatly from region to region. As a result, drought is highly context and region specific, requiring responses that are tailored to a particular situation. Identifying drought requires answering the question: water supply for what?

A second challenge is tracking and forecasting drought given the quality and coverage of existing data and the numerous concerns about many of the indicators used to track drought prior to 2000. Participants raised concerns about existing data – which indicators, indices, and datasets to use – and how it is selected to measure and track drought, highlighting the possibility that droughts and other climate hazards are not being properly studied. Good data – however it is deemed “good” – is often very limited. This is particularly true of historical data, which in turn affects the accuracy and utility of forward projecting climate hazard models. Drought data for Africa, in particular, appears to be problematic, albeit useable for research given the lack of any alternatives.

Most historical meteorological data is confined to the national level. Scholars and policymakers are increasingly aware that the variations that occur within states are often more important than the variations that occur across the African continent at large. Therefore, historical data can at times fall short in helping policymakers plan for future instances of drought.

A good drought model should be able to:

- Explain the past;
- Understand what will take place in the future; and
- Identify areas of immediate or emerging concern.

However, the very nature of drought makes achieving any of these three goals inherently difficult, if not impossible. Droughts do not look the same across regions. This limits comparability. Furthermore, droughts do not occur at evenly distributed periods across space and time. Unexpected rainfall or rain shortages, seen as distinct hazards and therefore modeled separately, greatly influence drought hazards.

Drought is measured not only by precipitation levels, but also by the resulting impact., There is no universal way of categorizing or measuring the impacts of drought. Understanding the effects of drought depends on the research question at hand (e.g. reduction in crop productivity, increased food insecurity, migration). Direct effects of drought include erosion, desertification, and reduced agricultural output, which affects both food security and job security for farmers and pastoralists alike. Indirect effects of drought potentially include economic decline, long-term reduction in agricultural production, changing migration patterns, and social conflicts. As a result, drought effects are not constricted to drought areas alone and the indirect impacts can be felt many kilometers away. Ultimately, the severity of the drought depends on water availability, how water resources are used in a given community, and how that community responds to shortages. The social nature of climate hazards makes understanding the local culture important in devising responses. Although scarcity is commonly viewed as a source of conflict, droughts

have resulted in increased cooperation in some areas, including the creation of resource-sharing agreements and treaties.

Whether existing data and available indicators are sufficient to analyze historical climate hazards or prepare for future ones rests on the question being asked. A range of possible indicators for measuring drought exists, including: rainfall, temperature, soil moisture, growing seasons, available surface water, and “greenness” (a normalized vegetation index). Only a few of these indicators, however, are good at measuring *past* climate hazards and hotspots. Furthermore, few of these models are especially good at projecting *future* hotspots and hazards. At present, no combination of these indicators can measure all three vulnerability outcomes of interest: past shocks, future shocks, and hotspots.

SESSION 2: REGIONAL CLIMATE MODELS

Session Objectives: Areas of future vulnerability to climate change may be different from areas historically vulnerable to climate hazards. Models and projections of future climate change therefore complement records of historical exposure. However, climate models tend to have difficulty providing fine-grained regional projections and also have difficulty validating past weather patterns. Moreover, most climate models produce projections for 2080 to 2100, far beyond the time horizons of most policy planning. What are the most promising avenues for generating regional projections on time-scales relevant to policymakers? How can these projections validate historical weather patterns?

Fine-Grained Models and Bias

The demand for more fine-grained models of future climate change is based on the observation that global climate models have coarse resolution and therefore may introduce bias – systematic errors between the model data and observed results – by ascribing broader regional patterns to an area without taking into account differences like elevation. These models may do a good job in depicting global patterns, but they do not do a good job capturing regional climate patterns at higher resolution. This is a particular problem for replicating historical rainfall patterns. If the models cannot replicate past rainfall and temperature patterns at the regional level, how can researchers and policymakers have confidence in their future projections?

In an effort to provide more regionally accurate climate models, scientists have employed a number of strategies. These are broadly distinguished between so-called “downscaled” global climate models (i.e. general circulation models or GCMs) and regional climate models (RCMs). There are different techniques to downscale GCMs, broadly distinguished between “statistical” downscaling and “dynamical” downscaling.

For the purposes of this workshop summary, the distinctions between these climate models are less relevant than the observation that each has strengths and weaknesses. Some, like dynamical downscaling, are more computing-intensive and expensive than others. Downscaled models share a number of drawbacks; many of them merely replicate the biases of the GCM models upon which they are based. Regional climate models seek to increase the resolution of GCMs, covering an area like the size of Western Europe or southern Africa. By being able to include elements of local topography and coastlines, RCMs may be able to provide more accurate projections of local climate dynamics at a scale of 25 to 50km.ⁱ

Short-Term Time Horizons and the Problems of Noise

Policymakers have short-term time horizons and are thus more likely to be interested in nearer-term climate projections. Climate simulations for the short term (2020 to 2030) and medium term (2040 to 2050) can be generated, but the problem of noise – reflecting natural chaotic variability in the climate system – means that it may be difficult to distinguish the climate signal from natural variability. Because rainfall varies significantly in the tropics within and between years, a strong climate signal will be slow to emerge from natural variability.

Model runs that focus on more near-term outcomes, which are of interest to policymakers, may not show a strong climate signal compared to end of century projections that are likely to show a clearer climate signal. Even at decadal timescales, the system has a lot of natural variability. The challenge of model building is distinguishing between climate changes that are (1) caused by man (anthropogenic forcing), (2) caused by nature but reflect systematic processes that are potentially predictable, and (3) the result of truly random or residual effects.

Though policymakers would like precise predictions of certain outcomes, the challenge is that models cannot produce a single right answer that distinguishes between each of these three sources of climate change. Model projections ultimately contain considerable uncertainty about future states of the world and the impacts of climate change. Although uncertainty cannot be removed, it can often be quantified, allowing researchers to communicate in probabilistic terms the likelihood of certain outcomes.

Improving Model Projections

The scientific community is actively engaged in developing more fine-grained models that provide more accurate projections of future climate change at the regional level for time horizons close enough to the present to be relevant to decision-makers. Despite these efforts, the challenge is difficult, as climate models have a number of inherent limitations given the complexity of the subject matter.

At best, scientists may be able to generate a number of different models and compare them to each other and to historical weather patterns. To the extent that the models converge in their expectations and do a good job of mirroring past weather patterns (what scientists call “validation” or model “fidelity”), users may be more confident that they are likely to accurately project future patterns.

Model validation involves careful comparison of the model’s projections to actual historical rainfall patterns, which are far more difficult to project than temperature. Here, scientists not only aim to mirror total rainfall amounts but also whether or not the projections mirror past patterns of seasonality and geographic dispersion, with special attention to their ability to capture extreme weather events.

However, models are likely to generate a range of different projections, and researchers may have to settle for a multi-model average or “ensemble” mean. Models may produce widely discrepant findings so an ensemble mean could even these out without offering improved accuracy. Where models produce widely divergent projections in terms of the direction and/or magnitude of projected rainfall, considerable effort needs to be invested to try to understand the source of those differences.

Even if models agree, they may suffer from common biases that undermine the accuracy of future projections. Just because models do a good job capturing past weather patterns does not mean they will necessarily do a good job projecting the future, especially if there are major discontinuities in how the climate system behaves.

Another challenge for modelers is the degree of completeness that is required to produce reasonably accurate projections of the future. A model is necessarily a simplified representation

of the world. It includes a number of parameters and inputs but excludes factors that are regarded as irrelevant to the focus of study. For example, other human activities related to land use and land cover, particularly at low latitudes, may affect the climate. However, not all of these factors are modeled or easy to model even though they may ultimately be as important as greenhouse gases.

Decision-makers who want a single projection of future climate change that is 100 percent certain on the timing, severity, and location of climate events are likely to be disappointed. Scientists may be able to provide a range of probabilistic statements about future climate change and be able to detect a signal of human-influenced climate change, but given the inherent noise in the system, the climate signal may not be strong until later in the century.

SESSION 3: SOCIAL SOURCES OF VULNERABILITY

Session Objectives: Vulnerability is only partially a function of physical exposure. It is also shaped by household and community resilience and the capacity of local communities to protect themselves from the negative consequences of climate change. What indicators best represent household and community resilience?

Analysts and policymakers have struggled to define a common narrative that explains vulnerability, measures it accurately, and allocates aid effectively. Defining vulnerability requires going beyond the physical effects of climate events to understanding the context-specific dynamics of communities, including the social, political, and economic factors that contribute to vulnerability and resilience. The measurement of vulnerability is important to ensure scarce resources are distributed to people most in need. Adaptation aid faces the dual challenge of identifying the most vulnerable and overcoming the well-known challenges of foreign assistance.

Describing Social Vulnerability

Researchers face a significant challenge in selecting the proper unit of analysis to measure indicators of vulnerability. Some have used counts of persons killed and affected per capita by past natural disasters in a country as a proxy for that country's vulnerability. Beyond the national level and counting the numbers, "drilling down" to the subnational, community, and household levels reveals different, and often competing, interests at each level. These differences help to explain the variation across regions and across countries. At the national level, there exists a substantial gap in vulnerability between developed and developing countries. However, similar gaps appear in the analysis of middle- and low-income nations where there are clusters of poverty and wealth resulting in some groups facing high vulnerability while other groups enjoy high economic and social resilience.

One can think of vulnerability as an onion with several overlapping layers representing the various factors that contribute to an individual's level of vulnerability. It is not practical to truly measure all of these factors, and current indicators handle competing vulnerabilities poorly. Choices must be made as to what factors to include in any analysis, but this choice risks missing some important elements of vulnerability. In selecting variables and metrics for measuring vulnerability, economic concerns have often trumped other factors. For example, commodities that are important for livelihoods are given priority in monitoring vulnerability. Ideally, the research community would be able to work with variables that scaled easily from the local to the national level, and could apply expert opinion where measurement of a variable is lacking in a certain place or at a certain level of analysis.

Vulnerability Is Context-Specific

Vulnerability is highly context specific. A one-size-fits-all metric does not suffice. For example, at the household level the level of poverty can result in very different outcomes and concerns. The poorest of the poor are most vulnerable in housing; those a tier above have to worry most about loss of livelihood diversity, while those with still higher incomes may face the greatest impact from loss of income earned in industry. Other relevant individual factors include

personal health, the ability to work, education, and employment opportunities. Several social variables, although difficult to measure and quantify, may be key to a person's ability to survive or thrive in a crisis including: the level of connectedness (whether an individual has an effective network of social, economic, and environmental relationships that provides a social safety net), the degree of settledness (whether an individual can depend on conditions being similar from day to day and from year to year), and the scope of available choices (whether an individual has alternative courses of action).

Food Insecurity

Food insecurity is one of the most complex and important issues that must be captured in an effective model of vulnerability. In Africa, 95 percent of the food consumed is grown on the continent and in many regions as many as 80 percent of livelihoods are directly dependent on agriculture. The adaptive capacity of food systems is quite low; even a local drought can bring on a food market failure. Current forecasts for the 21st century envision increasing populations and changing agricultural conditions that will place severe strain on the continent's food system. This pressure can be broadly categorized as a geometric increase in demand against a linear increase in food production; or more simply put, demand that far outpaces supply. Even if food production is a problem in some places, more often than many realize, food security crises result not from a lack of food in a region but from a lack of purchasing power to acquire the food that has been produced. Price instability in staple markets has increased vulnerability in some African locales, where populations have faced difficulty coping with the 150 percent price swings in the cost of millet in recent years.

Measuring and Monitoring Food Security Vulnerability

Understanding food security vulnerability requires both deep local knowledge and a global perspective. It is insufficient to know the global price or production levels of a given commodity without knowing the local context in which individuals must access that commodity. Measurement also requires a combination of the natural and social sciences through the collection of biophysical data (e.g. rainfall, vegetation, production indices) and socioeconomic and livelihood data. One method of measuring vulnerability is to address three aspects of food security: availability (regional production), access (purchasing power), and utilization (individual nutrition levels).

Efforts to measure and monitor food security are complex and labor-intensive. In many cases, critical data can only be collected by people physically collecting the data; for example standing on borders and asking truck drivers about their cargo and destinations to determine the availability of food or asking about local prices in markets. The most established monitoring projects in this area are the initiatives of the Famine Early Warning System Network (FEWS NET). FEWS NET projects combine on-the-ground infrastructure-mapping, market price-checking, and transported goods surveying with space-based remote sensing to map composite indices of near-term and medium-term vulnerability. The diverse experts working with FEWS NET achieve useful results in part because they use both biophysical and socioeconomic data. However, current weaknesses in the approach include: poor coverage of urban food insecurity (because many of the metrics used for rural populations simply do not exist for cities) and the high diversity of situations and range of policy responses (making generalizable conclusions hard

to draw). While FEWS NET is successful in measuring food security, concerns were raised that trying to combine its techniques with climate forecasting data to predict complex events in the long term risks diluting the effectiveness of the approach.

The role of remote sensing in providing ever-finer data about ground conditions has been expanding, largely through space-based instruments. Advanced Very High Resolution Radiometer (AVHRR) data from NASA have been used to establish a 30-year dataset that generates the Normalized Difference Vegetation Index (NDVI). Certain NDVI changes are significantly associated with an increased risk of mortality in the two driest countries covered, Burkina Faso and Mali. New remote sensing data collection, especially for large precipitation events, is currently under development by NASA and its partners but may not result in usable data before late in this decade, with a mission to conclude in 2017.

Financing Adaptation for Vulnerable Populations

The methodology of determining what kind of investment is required for risk reduction in vulnerable areas, what the proper distribution of support looks like, and where adaptation resources should come from is inevitably bound up in politics. It is unlikely that there can be an agreed-upon “scientific” algorithm that will settle any of these questions definitively. The emerging process of providing adaptation assistance has tended to center on donor pledges of arbitrary monetary amounts and application procedures that prioritize projects ready for implementation, rather than assistance driven by a coordinated approach and unifying principle.

Available Resources

The first concern is the actual supply of resources that will become available and how to raise “new and additional” climate adaptation financing. Despite a number of international summits and negotiations since 1992, there is no general agreement about the amount of funds that will need to be allocated to climate adaptation. Current estimates of annual requirements range widely from \$10 billion to \$100 billion. One workshop attendee indicated that current adaptation would require an estimated \$30 to 90 billion annually, plus hundreds of billions more for mitigation efforts.

The pledging process has also followed a rocky path. Talks in Marrakech in 2001 resulted only in token voluntary contributions. Paragraph 8 of the Copenhagen agreement promised \$30 billion for 2010 to 2012 and set a general goal of \$100 billion per year of public and private finance to be flowing by 2020. However, the ad-hoc nature of the system still reflects the vague way in which so-called “common but differentiated responsibilities” among states has been realized in practice. The goal of \$100 billion per year is challenging to attain and it is unclear how much will be dedicated to true adaptation projects.

Aid contributions do not currently flow through a single, structured authority. This situation will not necessarily change in the future. Future funding could have a strong multilateral character through trusts operated by the World Bank, which could reduce the political nature of allocations. However, it remains unclear what proportion of adaptation funding will come from global agreements and flow through multilateral institutions. The politics of relations between individual states and groups of states will play a strong role in determining how adaptation

funding agreements are put in place. Currently, aid is a mix of public, private, bilateral, and multilateral contributions, which may be based on alternative finance mechanisms. One specific point of contention in the professional community working on adaptation aid is the appropriateness of some of this aid taking the form of loans rather than grants. There also remains a question about when significant contributions will start to arrive.

Allocating Adaptation Aid

One of the most complex and vexing question confronting adaptation finance is how to allocate available funding. However, without a clear principle for determining who is “most vulnerable” or a unifying standard for prioritizing allocation, such determinations remain wide open. An allocation directly based on vulnerability to increased climate-related hazards could ignore the variation in resilience among groups that share a common geographic exposure to climate hazards; i.e. some groups may possess a stronger capacity to absorb these impacts.

The unit of analysis is also a challenge in allocation decisions: Should the focus be on individuals, communities, or states? The Bali roadmap prioritized adaptation funds to the “most vulnerable nations,” emphasizing the state level. The most vulnerable included three categories: Africa, the 45 least developed nations, and the small developing island states. However, within these national categories there are groups that are relatively less vulnerable, and there are others outside of this categorization that may be extremely vulnerable. Many participants suggested that analysis at the state level alone would thus miss the broad distribution of true vulnerabilities.

There is also concern that a “race to the bottom” competition for funding creates perverse incentives for countries to argue only that they are very vulnerable in order to receive needed funding. Such an incentive structure may prove difficult to make accurate evaluations of countries’ needs. States also continue to differ on the factors they weigh as most important in determining vulnerability: Bangladesh argues that priority must be given for reducing deaths, and small island states emphasize the need to stave off property damage and homelessness. A further complication is that countries with better institutional capacity – those with the international connections to make a strong case for receiving aid – may be prioritized over those states whose destitution is reflected in their lack of diplomatic ties and inability to put forward compelling proposals for assistance. Some workshop participants suggested that a proposed cap on the amount a country, or perhaps a region, could receive might help to increase equity, albeit artificially. Thus far, donors have prioritized wide distribution of funding and identifying urgent, ready-to-implement projects.

Governance challenges are highly pertinent to considerations of aid effectiveness: What would fair participation and control of funds look like? How can donors ensure funds reach the local level? How can donors ensure funds reach politically excluded groups, which may be the most vulnerable? Those states with the poorest governance – where money is most likely to have a limited impact or be lost to corruption – may be the very places where vulnerability is highest. Furthermore, prioritizing awards to short-term shovel-ready projects may not leave funds for longer-term needs. The international community is faced with a dilemma: Should donors send resources to the most well-established and convincing proposals or try to proactively search for the most vulnerable places that may not be presenting their needs effectively?

Investment in better project monitoring and data analysis systems will play a central role in resolving that question. Workshop attendees stressed that adaptation funding should not be allowed to suffer the ills of past development aid efforts, where accountability has been traded for local participation and control. Currently, donor governments lack good data about what resources are going where, and also lack data that drills down within projects themselves. Workshop participants suggested that the key to overcoming this problem is to understand that outside assistance will only provide a small fraction of what is required. In the end, people most severely impacted by climate change will have to spend their own money to adapt. External aid should therefore focus on being catalytic and supportive of national and local efforts.

Understanding Adaptation

Tradeoffs need to be considered within adaptation projects themselves. Adaptation projects are not simply an “unmitigated good”; sometimes they have negative unintended impacts. For example, a dam or levee can provide water or protection for one area but divert harmful floods to another area. Anytime choices are made to deliver resources in one place, an inequality can be created in another that risks becoming a driver of social conflict. The common approach to adaptation funding has been top-down with donor funding often requiring recipient countries to take a certain course of action. Some agencies are drawing on lessons learned, aiming to have recipient countries define appropriate adaptation strategies and build local domestic capacity to implement them.

Aid agencies, to intervene effectively, need to know what there is to build on, not just what is wrong. They need to know where the community institutions and organizations function well to help people in their households and communities. The most successful projects will build on these successes. Failed projects, by contrast, tend to push their own agenda and try to change the whole structure. Improved analysis of contexts and related interventions uses a governing concept that is not just government, but also includes an understanding of social values, institutions, and organizations that together make up how people live.

Vital adaptation projects might fail if they do not work within an existing social framework in the recipient country. In some cases the incentive structure for adaptation-focused development projects may not provide sufficient inducement to act. For example, some countries are risk-averse to adopting new programs or have low rates of technological adaptation. Some African countries have failed to take advantage of economies of scale in agriculture for social and cultural reasons. However, empirical evidence suggests there has been rapid adaptation to certain suitable technologies, such as mobile phones.

Measuring the extent to which adaptation occurs in a place will be necessary. However, there is no research consensus on how such measurements should be framed, much less quantified. One workshop participant emphasized that adaptation can entail “a total and utter loss of your way of life” – having to transform what people do, who they are, what they eat, and all of their cultural traditions. In such cases, adaptation is not about learning how to maintain what people are doing now, but about being forced to do something completely different in order to survive.

SESSION 4: GOVERNANCE AND VIOLENCE MAPPING

Session Objectives: Whether or not communities are protected from the worst consequences of climate change may depend on how willing or able their governments are to protect them. Areas with a history of violence or where certain groups lack political representation may be most vulnerable to being ignored or discriminated against for disaster relief or climate adaptation services. What indicators best capture localized governance failures and conflict? What indicators are most relevant for climate security consequences?

Units of Analysis

Until recently, most of the empirical quantitative work on climate and conflict has used the nation-state as the unit of analysis. Even studies that focused on internal conflict often assessed the topic in terms of the frequency of events by state with explanatory variables based on national indicators.

However, acute resource scarcity is locally felt. Civil wars, and even more so inter-ethnic violence, rarely engulf entire states. Since the early 2000s, there has been an upsurge of disaggregated analyses on conflict, though rarely have there been discussions of the appropriate unit of analysis. Scholars often make these decisions based on data availability rather than on the basis of theory.

Efforts to localize and study subnational climate vulnerability, including the connection between climate change and conflict, inevitably raise questions about the appropriate units of analysis. There are several options, including administrative units, grid squares, and ethnic groups, each of which has distinct advantages and disadvantages.

Administrative units may be politically relevant and benefit from data availability, but they may serve different functions in different states. Their boundaries can be the subject of contestation and conflict. Vast differences in size may make them less comparable using statistical methods.

Grid squares are of common size and, unlike administrative districts, their boundaries are exogenous to social processes. These features may make them more tractable for statistical analysis, particularly in the analysis of spatial dependence. However, data are not collected at the administrative unit level, creating difficult choices about how to aggregate data that cuts across administrative units in single grid squares. There is no minimum amount of social interaction for a grid square to be included in analysis. Some grid squares may not be politically relevant (such as those located in an uninhabited desert), which raises issues about which units to include.

Ethnic groups are another possible unit of analysis. Like administrative units, these may be important sources of identity and exclusion and thus politically salient. However, efforts to map them presuppose that they have clearly defined geographic habitats. A focus on ethnic groups assumes that political interactions are inherently of an ethnic character when other sorts of social cleavage may be as or more important in different settings.

In sum, there is no silver bullet. All three main approaches of selecting units of analysis have some potential drawbacks, though it may be possible to use several different units in a single study.

Governance and Vulnerability

Who is deemed most vulnerable has important implications for how governments respond in times of crisis and who receives assistance. Areas of increased vulnerability, particularly the populations within these regions, are more susceptible to climate shocks, and these shocks are more likely to influence ways of life. Too often responses to climate change are viewed simply within the context of how to best adapt without accounting for the consequences of not doing so. Climate change is increasingly seen as an issue to be addressed within the security field because climate shocks can amplify the already precarious positions of the most vulnerable populations. Failure to address the needs of the most vulnerable can introduce new security threats through the movement of populations and the augmentation of grievances. This raises important questions about governance. Can stronger governing institutions better buffer their populations from climate shocks and address the needs of those most affected by them?

Ethnic Power Relations

Acute resource scarcity is most strongly felt at the local level. Policymakers and researchers need to understand how climate change is felt at the sub-national level. Areas with a history of violence or where certain groups lack political representation may be more vulnerable to negative consequences following climate change shocks. These populations are the least prepared financially and in terms of capacity to cope.

Sub-nationally, local fragmentation is often felt along ethnic lines. Therefore, it is crucial to understand how ethnicity affects governance, and how patterns of governance might have larger implications in ethnically fractured areas that are susceptible to climate shocks. Collaborative efforts to address this issue-area have developed. One such endeavor is the Ethnic Power Relations (EPR) initiative.

The Ethnic Power Relations index examines the rise and fall of politically relevant ethnic populations within Africa between 1946 and 2005, measuring which ethnic populations have a voice (and thus access to power) at the central-governing level at different points in time. The index suggests that those populations with more advantageous positions within governments are more likely to receive assistance (be it political, economic, or social) when needed to respond to climate shocks. Conversely, groups that are politically less relevant are more likely to be vulnerable to climate change and less able to access assistance. Similarly, recently “demoted” populations – meaning those groups who recently fell from status as “politically relevant” – are also likely to be disproportionately vulnerable to climate change. “Irrelevant” groups who have lost political representation are more likely to be ignored by the government or discriminated against when disaster relief or climate adaptation services are delivered.

While including a measure of ethnic power adds value to mapping the socio-economic impacts of climate change within a state, it also raises broader questions over how to understand “vulnerability” and “political relevance” in the context of climate change. How can it be known

whether someone speaking for an ethnic population actually has the authority to speak for that group? What catalyzes a group to become “relevant”? How does vulnerability and relevance change over time?

Caveats on Conflict Data

New patterns are emerging as scholars increasingly shift their focus to non-traditional security threats. Have patterns of violence been affected by exposure to climate-related hazards? This is difficult to measure. Recent analysis suggests that the impact could depend on the type of hazard. For example, CCAPS research has found that extreme rainfall tends to result in an increase in violent social conflict, with wetter years being two times as violent (in terms of per capita deaths) as normal or dry years. In civil wars, a similar pattern occurs, with wetter seasons providing a better predictor of violence. These findings suggest that plenty, not desperation, is one driving factor for violence. Human beings are mobile and strategic about where they stage conflicts, so even if the change in the natural environment takes place in one location, conflicts that might arise from such changes may take place in more strategically relevant locations like capital or provincial cities. More detailed and localized data on conflict is needed to properly assess the relationship between environmental factors and conflict.

To date, much of the disaggregated data on local conflict is reliant on anecdotal accounts in news reports. This severely limits the quality and scope of data, as there is little systematic coverage across time and space. As with the climatic models discussed earlier, better governance and violence data are needed to accurately assess both the bio-physical and social impacts that climate shocks will have on populations, particularly those deemed most vulnerable.

SESSION 5: VULNERABILITY INDEX MAPPING

Session Objectives: Can the diverse sources of vulnerability indicators be combined into an index of vulnerability? What indicators should be included? How should researchers determine which weights should be attached to particular indicators?

Researchers face two challenges in identifying vulnerability – better defining the variables and their error ranges; and, creating data products that effectively communicate their findings visually without misleading or confusing audiences about how much of the “truth” is known. The quantitative description of vulnerability, both in its geophysical and social components, is plagued by uncertainty. Some of this uncertainty can be successfully quantified, while some cannot. Further, there is not yet broad agreement on the proper variables of inclusion for vulnerability. When these findings are placed into maps and index rankings, these formats do not effectively communicate the uncertainty of data or model ambiguity.

Components of Vulnerability

$$\text{Vulnerability} = \text{exposure} + \text{sensitivity} + \text{adaptive capacity}$$

The above equation provides a simple starting point for expressing vulnerability: Exposure is the raw physical hazard; sensitivity is the current susceptibility of the human system (e.g. infrastructure, health, agriculture) to that hazard; and adaptive capacity is the ability of that human system to change in response to environmental pressure. All three sub-indices can be mapped separately or in combination.

A combined index would include all three sub-indices, one for each of the right-hand-side variables. In one approach discussed in the workshop, the exposure index is weighted twice as much as sensitivity or adaptive capacity. The audience for the information may be important to the weighting and, as a result, to the understanding of vulnerability for a given purpose. For example, in supply chain applications, the exposure element may be emphasized; for relief efforts the sensitivity element; and for development initiatives the capacity element.

Exposure refers to the level of physical exposure of a population or land area to a particular hazard such as drought, flood, cyclone, or landslide. Identifying future exposure is, of course, dependent on climate modeling techniques discussed at greater length in earlier segments of the workshop.

Vulnerability includes a contentious component – the population density of the areas affected by natural hazards. If a moderate per-person risk hazard is being multiplied by a large number of people, this can show up as very high risk in a mapping project. However, high density in a city in a wealthy area is not necessarily an indicator of vulnerability and may mislead an audience. Therefore, one participating research group tried to shift emphasis to a per capita resources approach. Thus, maps depicting resource availability (such as volume of rainfall) were scaled in per capita terms. It is important, then, to understand how mapping data is going to be used to make the decision about gross vulnerability vs. per-capita vulnerability. The former might be more valuable in decisions about the total resources that need to be devoted to an area. The latter, however, may be more useful in aiding the search for those most in need of a set, limited amount of adaptation aid. In either case, the heavy inclusion of agricultural data that show gain

or loss of suitability due to climate change may cause problems for assessing vulnerability in increasingly urbanized populations that become less directly dependent on local agriculture.

A sensitivity index developed by one of the workshop participants reflects the level of sensitivity already in the system. This includes variables such as access to information and infrastructure, access to health services, dependence on agriculture, extraordinary vulnerability in the populace (e.g. conflict risk, presence of displaced persons, etc.), natural resource pressure, population pressure, and economic resources. Some of these variables can be measured sub-nationally. Other measures of sensitivity focus more on agriculture, such as the amount of land irrigated, rainfall per person on agricultural land, and available soil moisture. Sensitivity data tend to be easier to find at the sub-national level than exposure or capacity data. Some of these variables are included in the “adaptive capacity” index of some studies.

The adaptive capacity index reflects the ability of a system to adapt to change. Variables within this index tend to be measures at the national scale. The differentiation between sensitivity and adaptive capacity can be demonstrated through economic resources. Sensitivity is sub-national poverty distribution, whereas adaptive capacity is measured by national GDP and willingness to distribute it. On health, sensitivity is proneness to disease, whereas adaptive capacity is measured through life expectancy.

In the work of one group, the composite index is a national score that accounts for the mean sub-national index score, the most extreme score within the country, the absolute area at high or extreme risk, and the proportion of the country at high or extreme risk. Additional indicators for adaptive capacity include: GDP, malnourishment, improved access to water, and presence of lights at night, along with other development and disease indicators. In tandem with these ideas, they discussed biodiversity security as a component of particular focus: it is essential to understand how intact ecosystem services are and how well they are managed (e.g. protected areas like national parks).

Map Display and “No Data” Challenges

The availability and quality of data pose challenges to analyzing data. Data coverage on this topic can be spotty and variation can be great. If a map scale is calibrated to the extremes that are being displayed at any given moment, then mapping risk indices on a global level could mask intra-regional variation. However, if mapped at a very local scale, fairly minor differences could be blown out of proportion. Indices can also lead to rankings, but this raises questions as to whether researchers should divide results into quintiles to establish general vulnerability categories and de-emphasize ordinal positions. The most vexing question is how to deal with data gaps. There are notable gaps in most datasets that involve developing states. For example, Western Sahara, French Guiana, North Korea, and Somalia are frequently left out altogether. Sometimes a generally poorer and less accurate dataset is chosen because better coverage is desired.

Gaps may exist in missing data for a country and there may be a lack of data at the desired scale. For example, government effectiveness can operate at a national scale, but a researcher may only be using national data because sub-national data is not available. Can national or sub-national data be cross-substituted conveniently and without a great deal of penalty to the fidelity of the

result? This is difficult when there are differences between countries in how administrative levels interact and how data is collected in different units of government. At a more general level, some types of data (such as heat stress mapping) will be much sharper than other types, such as corruption.

Communicating Confidence Levels

Researchers face significant challenges in communicating the limitations of data and models when presenting findings through maps and indices. Often, audiences ignore the explanation of what the index model *cannot* do, and instead focus on the visual presentation of the data. The presentation of data should try to limit the chance that an important decision would be made based on a poor reading of a map (e.g. simply because one pixel is shaded differently than a neighboring pixel). Partly, this problem is inherent in the current medium: Maps do not have error bars, and so they can be deceptively authoritative. Even when a map shows a single variable, there is no broadly understood way of displaying its margin of error. This becomes even more difficult when different index inputs, with different corresponding levels of uncertainty, are being added into a larger model.

One approach to trying to understand the robustness of spatial models is to conduct visual sensitivity analysis. The use of overlay modeling can highlight how sensitive the assessments of vulnerability for various regions are when the input variables are adjusted, and thereby identify general “hotspots” of vulnerability and centers of resilience. In iterative analysis, the hotspots remained quite robust through different iterations of the model using different variables, resulting in a higher confidence in the accuracy of the model. The hotspots from one of the models that was discussed are, however, quite different than those developed by earlier CCAPS modeling.

A key challenge in the development of indices is the potential collinearity of variables. Workshop participants expressed two sharply different views on the problem. One view highlighted the fact that many of the variables used in different parts of an index track together (and track closely with GDP). If more than one variable is measuring the same effect, then building index maps that simply add these variables together may be amplifying an effect that is either flawed or has only modest explanatory power. The more variables that are added that simply duplicate each other, the less reliable and more deceptive a “hotspot” map becomes. A second view underscored the point that just because variables are correlative, that does not mean that they are not additive. If there is theoretical support for the relevance of each variable, then the stacking of collinear observations is simply a consequence of the reality: that in poor countries, these various risks and deficits really do add up to heightened vulnerability. If this is the case, then the problem is simply one of getting the weighting right, and the models are in fact useful and not replaceable just by mapping one of the variables. The problem of collinearity may be an especially difficult one to solve: because the variables *are* so collinear standard regression inference techniques may fail at providing robust evidence for how significant each variable is.

“Vulnerability to What?”

Although vulnerability maps can provide a simple illustration of risk, it is not always clear what “bad outcome” vulnerability maps are measuring. Confusion about outcome specification arises when vulnerability can take on a number of different interpretations depending on the interest of the audience. An important question to resolve is what these tools are being used to measure and project to the audience. One approach is simply to show climate vulnerability and not contaminate the map with other indicators or considerations. Another approach would be to identify predicted adverse social outcome given the occurrence of a particular event. From a security standpoint one obvious outcome of interest is the incidence of social unrest, as measured by, for example, the Armed Conflict Location and Event Dataset (ACLED) or Social Conflict in Africa Database (SCAD); another outcome of interest might be numbers killed or injured in an event. There are also some data consumers that have more narrow and specific areas of focus, such as how to allocate scarce resources, how to identify greatest need, how to locate the most vulnerable populations, or where there is capacity to absorb investment and put it to good use, even if those are places where the baseline conditions are not the most vulnerable.

Using Maps with Policymakers

When it comes to the use of index maps in discussions with policymakers, the vulnerability maps generally do not have a lot of surprises in them, and therefore they do not tend to be useful for causing a radical shift in thought about priority areas. Rather, they provide an easy reference for researchers to present a summary of their findings. For researchers, which layers and indicators are contained within the maps that contribute to the hotspots and rankings are of most importance, but policy makers may be more interested in the hotspots or the ranks. Providing a policymaker with a GDP per capita map is not useful in terms of creating an effective policy response. These vulnerability index maps are an entry point for a discussion about those conditions that are collocated with poverty, that underlie tragic outcomes, and that reinforce other factors in the vulnerability landscape.

Another challenge is a disconnect in the language used in the research and policy communities. Researchers tend to use the language of vulnerability, whereas in the context of national security and U.S. political leadership, leaders tend to be more receptive to acting on issues characterized as a “threat” rather than “vulnerability.” Speaking in terms of “U.S. interests” can also get more traction than the oft-overused “U.S. security.” It is important to communicate that the link between climate change and undesirable social outcomes may have a time dimension: Later in the 21st century, the causality may be more direct.

SESSION 6: SIGNIFICANCE OF MAPPING, DATA, AND MODELING FOR INTELLIGENCE COLLECTION AND POLICY

Session Objectives: How can these diverse sources of information be accessible to policymakers? What information would be most timely and relevant?

The U.S. government has recently incorporated major developments in its understanding of fragile states, relief and development partnerships, and environmentally sensitive operations into its planning for the future. This includes major investments in data collection and crisis early warning systems. These efforts aim to gain sophistication in understanding complex social interactions in vulnerable, conflict-prone states in order to promote aid interventions that avoid unwittingly exacerbating bad situations.

Previously, the “three Ds” – development, defense, and diplomacy – were involved in approaches to minimize environmental contributions to conflict and instability. Now, a wide variety of agencies in teams and bilateral missions confront these topics on a regular basis. The chief threat to U.S. national security interests from environmental sources, however, remains regional instability. It remains difficult to talk in terms of future vulnerability to politicians who have term limits and short-term objectives. Case studies in priority areas could help to make a better case for action.

The current national security leadership’s conclusions on climate change are:

- Global climate change will have wide-ranging implications for U.S. national security interests over the next 20 years;
- Climate change will aggravate existing problems;
- Climate change *on its own* is highly unlikely to trigger failure in any state;
- Climate change will potentially contribute to intra- or, less likely, inter-state conflict; and,
- Climate change will entail issues such as food and water security.

Need for Ongoing Capabilities

A 2010 report of the Interagency Climate Change Adaptation Task Force noted that domestic agencies “provide critical expertise...that can be used in an international context for development planning and national security analysis.” If people within the agency structure of government could perform the full spectrum of scientific analysis necessary to produce end estimates, then their skills could be leveraged more effectively than can be done by relying on the academic grant community or current contracting arrangements with academics. Drawing from the academic community is now at the heart of the U.S. government approach, but pulling reports off the shelf will not be as effective in the long-term as being able to produce data internally. Creating and modifying current internal assessments will require generating an analytical flow from the physical to biological to social to political science in order to capture the relevant factors. However, at the level of the end product, it becomes difficult to understand the cumulative uncertainties that have piled on at each level of analysis.

Workshop participants expressed the need for researchers to strategically seek out funding for research where it is most valuable, rather than simply allowing the people with the money to dictate from their own notions about what research should be done.

Agencies represented at the workshop expressed a need for help in the following areas:

- Analysis of the interface of climate impacts and policies with disaggregated elements of the conflict equation;
- Sub-regional and local data collection, analysis, and mapping;
- Integration with key U.S. government initiatives (e.g. global health, food, and water security);
- Transboundary analysis to inform regional strategies and programs;
- Principles for conflict-sensitive adaptation programs;
- Cross-sectional analytical tools; and,
- Support for local level analysis and translation of data into policy.

Early Warning

One emerging mechanism for identifying areas of interest and fragility are early warning systems. Policy planners are trying to move away from using civil war as the sole dependent variable (or outcome of interest) and look more closely at precursors of various types of conflict. The concept of fragility is now built into U.S. military contingency planning, theater engagement, situational awareness, and smart power response strategies designed to reduce the need for more costly interventions down the road.

However, fragility is difficult to measure. Fragility, in general, involves institutional weakness serious enough to threaten the stability of the central government. While it is conceptually distinct from instability, there is no internationally accepted definition. Fragility indices often rely on the same underlying data and similar analytical approaches to the vulnerability maps discussed in other parts of the workshop, and thus face similar challenges.

Organized, intelligence-driven efforts to obtain early notice of potentially serious security conditions are also being developed. Particular data considerations for these efforts include:

- Disaggregated/pre-coded data;
- Remote sensing;
- Expanded ontology of social unrest;
- Common frameworks such as fragility/vulnerability indices;
- Reduction of stereotypes;
- Transparency of indices;
- Computational social science methods;
- Information that facilitates interoperability of response agencies; and
- Swifter up-take of new internet-based collaboration and data-sharing technologies (driven by a community of interest).

Designing Conflict-sensitive Interventions

There is now a desire for a much better understanding of all the ways in which climate change is placing pressure on the conflict-generating process. Climate change is not going to intersect just at one point in the dynamic, nor will it intersect in the same way in each case. This underscores the importance of localizing the questions asked. Especially in the context of intervention, it is important to understand how the various factors intersect locally: Simply getting a general understanding of conflict causality is not enough. For example, the pressure of disasters may cause government resources to be used in response and recovery rather than investing in other areas, and there will be specific political tradeoffs made.

One workshop participant cited research that found there was very little empirical evidence about how conflict-generating dynamics are intersecting on the ground today. The 2010 annual alert list produced by USAID – which examines existing levels of fragility and predictions about instability – was the first to include an overlay with climate change considerations. Since two identical weather events can occur in two countries with only one experiencing social unrest as a result, clearly there are intermediary factors that stand in a causal chain between climate change and instability.

One current policymaker noted that studies assessing whether a causal link exists between climate change and conflict have produced widely varying conclusions. Workshop participants concluded that researchers must do a better job of identifying relevant factors and demonstrating their importance to events of interest. For example, showing the massive importance of rain-fed agriculture in a region, indicating a clear link between food insecurity and conflict, and demonstrating a corresponding need for interventions to focus on agriculture in food insecure areas.

Just because climate change is not considered to be “the cause” of conflict in a given area does not mean that it is not a generally important variable. If an early warning process can flag down general areas of concern, then knowledgeable practitioners can drill down into specific issues and make sure that the right local factors – whether climate-driven or not – are taken into account, thereby improving interventions. In interventions, what donors do can often be less important than how they do it: Being transparent and inclusive builds confidence and can help to minimize the tension-building effects of an intervention.

From a theoretical perspective on social conflict, aid agencies are focused on interactions and their additive effects. One starts out with grievances and resiliencies: These coexist and are not exclusive values. The analysis then looks for patterns of grievance that are significant (e.g. not simply getting mugged, but getting mugged every day and interpreting the experience as resulting from being part of a particular group). Then there are people or factors that mobilize grievances in one direction or another. These are conflict drivers and conflict mitigators. Conflict mitigation is not necessarily good: An effectively repressive regime, for instance, can efficiently reduce the likelihood of conflict. Trends tend to build in one direction or another, and when a triggering event occurs it can mobilize these grievances and resiliencies.

Funders need to be armed with knowledge about local conditions. Strategy needs to address how climate change funding will take this conflict dimension into account. The U.S. is developing new climate change adaptation guidance worldwide, trying to make it more conflict-sensitive so

that people working in missions can ask the right questions as they design interventions. There will be an important role for official facilitator organizations, like USAID, to act as the primary hub of communications, making sure that people working in one area know about the experiences and innovations of others.

Positive Opportunities

In addition to the risks associated with climate change adaptation, there are also opportunities. Significant funding for mitigation and adaptation is expected to become available in the future. If decision-makers are informed about the dynamics of conflict and not just the environmental or economic parameters of a particular situation, the security outcomes could be improved. Practitioners can also consider climate change sensitivity in the places where conflict vulnerabilities exist. It may be problematic, or even inaccurate, to always frame climate change in terms of its threat to stability. There is a growing body of research suggesting that, under certain conditions, disasters or resource scarcity can also be a catalyst for cooperation. Countries will cooperate on environmental issues in a transboundary way when resources are scarce and must be shared or managed collectively.

Research is needed to:

- Inform the structure of information-sharing services that pass data and expertise between partner agencies;
- Understand the dynamics of environmentally-influenced conflict well enough to provide simple, practical guidance for intervening actors that wish to be conflict-sensitive;
- Integrate the full spectrum of scientific fields – from the physical to the social sciences – to provide good intelligence in a way that is comprehensible and actionable;
- Expand the ability to predict larger regional security consequences from climate vulnerability so that better information can be fed to areas of government that are more narrowly focused on direct U.S. national security interests; and,
- Build capacity within federal agencies and at the sub-national level internationally so that authorities can develop consistent and trusted pipelines of information without having to rely upon sub-contracted analysis through one-off projects at universities that often do not continue research beyond the grant term.

CONCLUSION

The concluding session of the workshop offered a time for participants to reflect upon the discussions in the previous sessions. This resulted in a number of widely accepted assessments and some suggestions for future avenues of research.

It is increasingly important that policymakers and researchers work in more interdisciplinary teams. A common framework across disciplines and across professions is necessary to effectively research and respond to the effects of climate change around the world. Increased dialogue between policymakers and researchers in venues such as this workshop are necessary to better address response capacity to climate shocks. Efforts must be made to assess and reduce the gaps that currently exist between policymakers and researchers.

Data quality and availability dominated much of the discussions over the six sessions. In tandem, questions over how to select the most appropriate indicators played an integral part in shaping the direction of the conversation. Both policymakers and researchers agreed that it would be helpful for some future meetings to focus solely on measurement. One option would be to hold a workshop on measurement, similar in format and scope to the current workshop, in the near future.

The need for increased focus on measurement stems from the need to know the *why*. The scientific research on climate models is headed in the right direction. That being said, the science of climate change and its impacts will not make it to the halls of U.S., African, or international policy institutions if the *why* is not better highlighted. This means moving beyond using empirical bases to make descriptive statements and beyond identifying emerging trends and patterns, to understand why they are emerging, and which factors are driving these processes.

Policymakers are prone to focus most on crises, whether this is the correct model or not. Therefore, there is a need to provide policymakers with more information during these periods of crises that can also shape future action. To date, policymakers have been slow to accept and respond to climate change. In the end, some participants thought it may be less important whether anthropogenic climate change is actually the driver of vulnerability than understanding the consequences of large climate events, how we can predict them, how we can effectively respond to them, and ultimately how we can assist vulnerable populations in improving their resilience to climate shocks.

ⁱ For more information on global and regional climate models, see http://climateprediction.net/content/regional-climate-models#reg_mod. See also www.realclimate.org/index.php/archives/2007/05/climate-models-local-climate. For more information, see www.ess.co.at/METEO/regional.html.

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