Background Paper

Data Collection Challenges and Identifying Climate Change Drivers

A Synthesis of Discussions from the "Research on Climate Change Adaptation in Coastal and Delta Areas" workshop, co-hosted by Universidad do Pará and the International Development Research Centre (IDRC)

Belem do Pará, Brazil, October 2013

Foreword

The International Development Research Centre's (IDRC) Climate Change and Water (CCW) program supports research that improves water quality and availability for vulnerable communities, enhances the capacity of researchers to conduct climate change research and analyze results, and encourages the communication of results to potential end users.

CCW supports a portfolio of projects to conduct coastal adaptation research, considering that coastal zones are particularly susceptible to climate change impacts. Such areas often have dense concentrations of economic activity and human population, as well as high vulnerability to sea level rise, flooding, and storm surges. Climate change research in coastal areas is particularly challenging, given the complex interactions of multiple stressors.

Research teams from CCW's coastal portfolio of projects gathered to discuss common challenges and exchange findings at the "Research on Climate Change Adaptation in Coastal and Delta Areas" workshop, co-hosted by Universidad do Pará and the International Development Research Centre (IDRC), in Belem do Pará, Brazil on October 2-4, 2013. This background paper was validated at the above workshop, and includes contributions from the following IDRC-funded projects:

- 105674 The Power of Collaborative Governance: Managing the Risks Associated with Flooding and Sea-level Rise in the City of Cape Town
- 106248 Water Security in Peri-Urban South Asia: Adapting to Climate Change and Urbanization
- 106551 Establishing the Alexandria Research Centre for Adaptation to Climate Change (ARCA)
- 106597 Impacts of Climate Variability in the Coastal Areas of Argentina and Uruguay in the River Plate Estuary
- 106703 Strengthening livelihood security and adapting to climate uncertainty in Chilika Lagoon, India
- 106711 Socio-Cultural Adaptations of Caboclos Communities to Extreme Tidal Events in the Amazon Estuary of Brazil
- 106714 Impacts of Climate Variability and Climate Change on the Mangrove Ecosystem in Tumbes, Peru
- 106923 Risk Perception and Vulnerability of Wetlands Areas in South American Atlantic Coasts

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Introduction

The widely accepted definition of *climate change* is a change of climate, tied directly or indirectly to human activity, that alters the makeup of the global atmosphere and is compared over time with natural changes in climate. Therefore, in climate change research, identifying drivers is intensive work, especially when we assume that climate change is a man-made process. As such, "alterations in the atmospheric concentrations of greenhouse gases, land cover, and solar radiation alter the energy balance of the climate system and are drivers of climate change."[i]

A driver, in environmental science, is any natural or human-induced factor that directly or indirectly causes a change. A "direct driver" unambiguously influences ecosystem processes, such as pollution, habitat change, and invasive alien species. An "indirect driver" alters the level or rate of change of one or more direct drivers, such as population change and economic activity, as well as broader socio-political and cultural processes. A driver is, in short, the force that causes a reaction.

According to the Intergovernmental Panel on Climate Change (IPCC)[ii], ecosystems are affected by both climate and non-climate drivers. For instance, non-climate drivers such as urbanization and pollution can directly and indirectly influence climate variables, including albedo (i.e. how different surfaces reflect light) and soil moisture. Socio-economic processes, including land-use change (e.g., from forestry to agriculture) and land-cover modification (e.g., ecosystem degradation or restoration) can influence climate variables as well, which can then contribute to changes in local climate.

It is clearly a challenge to discern between drivers that are driven by climate change, and non-climate change drivers that can contribute to local changes in climate. It is important to distinguish between these two types of drivers to develop appropriate adaptation strategies for different scales of impact, and to minimize their impacts. This paper discusses the challenges involved in data collection and analysis for climate change research, as well as the challenges of discerning climate change drivers from non-climate drivers.

Data collection challenges are an issue in most environmental research, particularly when researchers are looking at the synergies, tensions, and linkages between biophysical and social data. Data collection for climate change research is especially challenging, given that this research works across multiple disciplines and draws on large amounts of data with various degrees of uncertainty. To add to this complexity, it is important to analyze historical data to identify climate change drivers or predict future climate scenarios. This last point is a particular challenge in developing countries, where historical data is either difficult to access or simply not available.

An important part of climate change research is to communicate and clearly represent the uncertainty generated by using different models (Stainforthet al. 2007)[iii]. There is a clear link between the challenges in data collection and our research methods. What data is collected and what methodologies are used in and across different disciplines is key to understanding different processes. Research methods each have inherent challenges around data collection and analysis, including issues of availability, quality, and scale (which come with varying levels of uncertainty).

Overview of Participating Projects

Discussion: Data Collection Challenges

Each of the projects that participated in the "Research on Climate Change Adaptation in Coastal and Delta Areas" workshop experienced challenges with data collection and analysis, and in identifying climate change drivers. Below is an overview of their respective experiences.

Sometimes challenges in the identification of climate change drivers are not associated with a lack of data, but rather on how to use the data to create an appropriate response and to do an appropriate statistical analysis

The *Power of Collaborative Governance* project in Cape Town has discovered that the city's problems studying rising sea levels come not only from a lack of data, but also from questions of how to use and analyze that data to create an appropriate response strategy. While the project had quite good tide gauge data from a South African naval base, the major challenge was gathering socio-economic data in informal settlements (on inland flooding), especially since some figures were disputed or uncertain.

In the *Water Security in Peri-Urban South Asia* project, researchers used both quantitative and qualitative methods to shed light on problems tied to water shortages, which are compounded by urbanization and climate change for vulnerable communities in peri-urban locations. This study looked at four South Asian cities: Gurgaon and Hyderabad (India); Kathmandu (Nepal); and Khulna (Bangladesh). This project saw that communities in the four areas, despite significant differences in landscapes and climate patterns, face similar social, institutional, and economic conditions, which made comparison easier. This project collected popular perceptions and climatic data gathered over time at the four sites. In most cases, the collection of long -term climatic data from weather stations was difficult because of the slow bureaucratic process involved in accessing this information. In some cases, it was unclear who was responsible for releasing the data. It was difficult to find weather stations at or near the research sites, as most weather stations were located deep in urban areas. Because of this, researchers decided not to add the spill-over of added heat from urban landscapes and atmospheres and the micro-climatic characteristics of the peri-urban areas to the analysis. Although in most cases perceptions on climate change matched the recorded data, in some cases these perceptions were influenced more by the effects of urbanization than climate change-related factors. In South Asia, urbanization and climate change are two critical stressors that severely impact the biophysical environment of peri-urban areas.

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The *Establishing the Alexandria Research Centre for Adaptation to Climate Change (ARCA)* project supported the launching of a research centre at the University of Alexandria, in Egypt. The objectives of the project were to build capacity in climate change adaptation through scholarships, training workshops, and mentorship, and to work with policymakers to create and support a policy-relevant research agenda. Although the Nile Delta has been identified as one of the regions of the world most vulnerable to climate change, relatively few integrated efforts to measure the future impact of climate change in the region had been made before opening this centre. The challenges that this project has identified for data collection have been around acquiring updated and accurate data from secondary sources, gathering useful amounts of data and information through field surveys, and integrating the data collected from different sources.

The *Impact of Climate Variability on the Coastal Areas of Argentina and Uruguay in the River Plate Estuary* project assesses the present and future vulnerability of both coasts to climate change effects, looking at what local communities face in the short- and medium-terms. To do this, the project accounts for actual and possible physical, socio-economic and institutional conditions. Working on two pilot sites in each country, researchers collect physical, social, and economic data, and assess the impact of climate change in relation to land use regulations and watershed management, producing a set of vulnerability and risk management plans. This project has identified different factors in climatic disruption changes, such as the intensities and frequencies in wind patterns and rainfall. The project has faced many challenges in data collection - mainly a lack of data and/or difficulties in accessing information. For instance, the project shows that there are no local records of climate events and water levels, nor damages caused by extreme climate events (including at a household level), and that there is limited quality control on the available data. When this data exists, public access is limited.

The *Sociocultural Adaptation of Caboclos Communities to Extreme Tidal Events in the Amazon Estuary of Brazil* project parts from these data-heavy methods, showing that, over the past three decades, the Caboclos peoples of the Amazon region have noticed changes in the tidal floods of the Amazon River's estuary floodplains. These changes have had a negative effect on traditional crop production, as well as some positive effects on traditional agroforestry, forest management, and fisheries. The Caboclos are adapting to these changes by shifting from cropping to agroforestry and forest management, as well as intensified fishing. A combination of pressures, such as changes in wind systems and precipitation (and thus flooding intensity and frequency) in the Amazon delta, has been identified. The preliminary assessment of the threatening relationship between sea level and changes in tides shows that the river level's variability is closely tied to rainfall in the region.

The implementation of any recommendations from these assessments is limited by a range of data collection challenges. Continuous tidal records for the Amazon estuary are either non-existent or available only for very short time periods. Similarly, sea level height data collected from satellites is sparse and collected at random hours of the day, making a comparison to tidal data nearly impossible. Other challenges for biophysical data have been the lack (or

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unevenness) of information on the impacts on soil (salinization) of increased flooding, and on temperature and rainfall changes with regards to crops. Finally, information on the relationship between socio-economic and cultural variables with regards to biophysical data is sorely lacking. An example of this is the absence of surveys on changes in land and resource use due to sea level rise (specifically data addressing the relationship between land use and socio-ecological systems). Even though information on traditional land and resource use systems in the region exists, if in limited form, it is typically from inland Amazonia, while very little work has been done on the relationship between land use and climate change in the estuary regions of the Brazilian Amazon.

The use of Integrated Coastal Management methods helps to analyze the multiple variables that affect wetlands management

Chilika Lagoon is a brackish coastal lagoon and biodiversity hotspot in the province of Orissa in Eastern India, where the *Strengthening livelihood security and adapting to climate uncertainty in Chilika Lagoon, India* project is taking place. The lagoon provides sustenance for more than 200 000 fishers and 400 000 farmers living in and around the wetland and its adjoining catchment area. In recent years, however, climate uncertainty and environmental degradation (in the form of salt intrusion and increased sediment loads) have affected the area's water systems (especially the relationship between fresh and saltwater), threatening livelihoods and posing a serious flood risk, particularly during the monsoon season. In this project, among other things, researchers forecast some scenarios of changes in the ecosystem due to climate variability. , looking at a range of variables. This has helped narrow down the modeling focus to predict scenarios. This method has helped researchers understand the lake's water systems and their linked ecological processes (such as fish migration and salinity). Even so, the utility of this information is only in interpreting the impacts of climate change, and not developing a local climate model. Weaknesses include developing a climate linked hydrological model for the Chilika Lake basin, which can explain interactions with riverine as well as coastal processes.

The *Impacts of Climate Variability and Climate Change on the Mangrove Ecosystem in Tumbes* project is located on the northern coast of Peru, a region strongly affected by climate shifts tied to the El Niño weather system. Because of this system, detecting climate change signals based on climate variables has proven to be a challenge. With this in mind, the project focused on only the most obvious variables when analyzing historical records, as this also allows for a larger sample (statistically), even in short records. However, since the length of the research project is only three years, this is regrettably too short to collect new data to check for more variability. To avoid these data challenges and limitations, the project has adopted two approaches. First, there has been a focus on seasonal cycles and differences across different sites; and second, other indicators closely related to the biggest variables were studied. Other regions were also studied to make the sample more robust.

The *Risk Perception and Vulnerability of Wetlands Areas in South American Atlantic Coasts* project takes place in Brazil and Uruguay. The project builds on the awareness that South American Atlantic coasts provide many ecosystem services (benefits brought to communities by ecosystems), yet are threatened by population growth, rapid land use change, mangrove deforestation, pollution, and water diversion. These threats make wetlands increasingly vulnerable to climate change, ultimately affecting the local population that depends on them for their livelihoods. Although there is an increased recognition (regionally and locally) of the connection between biodiversity and environmental services to support human welfare, local knowledge of the risk to ecosystems is low. This project will assess the connections between biodiversity, environmental services, and climate change in the wetland areas of Southern Brazil's and Eastern Uruguay's Atlantic coasts. Central to this project is the use of Integrated Coastal Management methods to help analyze multiple variables that affect wetlands management, as well as popular perceptions of risks tied to complex events such as long-term climate change. Based on this analysis, the project develops guidelines to encourage municipal and national governments to incorporate ecosystem services into climate change policies. Gathering information from different stakeholders about ecosystem services and their links to climate stressors has proved to be a major challenge here. This is because of the diversity of perceptions, languages and general understandings of technical issues. Also, sharing "basic" information concerning climatic, ecological, and social issues has not proven as useful as expected, since that information was produced for purposes not connected to this particular project.

Discussion: Climate Change Drivers

The Cape Town project has recognized flooding caused by more intense rainfall and rising sea levels, and more intensive storms, as drivers that expose poor land-use and infrastructure planning. Also, the project has further identified informal settlements (which are the areas most prone to flooding) as growing from in-migration from rural areas that are less viable due to climate change impacts on agriculture. In the 'peri-urban' project in South Asia, the climate change drivers (as perceived by the communities and verified by secondary data analysis) were the increase in temperatures in different time frames (seasonal, annual), changes in rainfall patterns, the salinity of fresh water, a shift in monsoon patterns, and changes in humidity and evaporation. Importantly, urbanization has been identified as one of the major forces behind changes in the micro-climate of the peri-urban areas.

The ARCA project in Egypt found sea level rise and the associated saltwater intrusion into groundwater to be key drivers, with rising temperatures playing less of a role. The River Plate Estuary project has identified trends in both the number of days with high precipitation and the number of days with high water levels (caused by winds during storm surges) as the main driver of climate change in the subregion.

Urbanization and climate change are two critical stressors that negatively impact the biophysical environment of peri-urban areas

The Chilika Lagoon project has identified several drivers, which include: changes in freshwater flows, which are susceptible to changes in rainfall, temperature, relative humidity, and other hydro-meteorological factors; sea level rise and related coastal changes; and land cover changes (e.g., deforestation) in the lake basin. For the Amazon River Basin project in Brazil, the main identified driver is river height, used as a proxy for tidal variations.

Many of these projects are pioneering, and therefore cannot build upon general knowledge

For the Northern Peru project, the key climate drivers identified and prioritized thus far are extreme precipitation and its associated river (freshwater) discharge, which carries sediment to the mangroves, and sea level change, with its influence on tides in the mangroves. These are all considered while keeping in mind how the influence of the El Niño-Southern Oscillation (ENSO) makes the identification of climate change drivers affecting the Tumbes mangroves ecosystem more difficult. The South American Atlantic Coasts project has identified different drivers for the different pilot sites. For one of the sites, flooding, extreme weather events, and wind pattern changes are the identified drivers. For another site, the only driver is flooding. For a third site, climatic drivers have not been identified as major stressors, but industrial (e.g., port) development is seen as a major pressure, which in turn can be influenced by climate factors.

Conclusions

The challenges in defining which data is valuable, on what scale, and in what relationship to other data are only growing more complex, and with the rising urgency of developing of local adaptation strategies for a changing climate, this is a challenge communities are meeting. Even so, communicating the challenges that surface when using different methodologies, and making the connections between different types of data accessible are still very real barriers to overcome.

There are difficulties in identifying or demonstrating causalities between perceived drivers and vulnerabilities or impacts of human-induced climate change.

Our general conclusion is that data collection challenges are more demanding in developing countries, given the lack of indicators or data in many fields as well as the lack of access to information and an absence of transparency with available data. Adding to this, data and information from the informal sector is also vague and unclear, or often does not even exist on issues Westerners might consider basic, or on climate change impact/damages for those outside formal economic circles and formal settlements. Insufficient knowledge of complex biophysical data (within usable time frames for analysis) is also a major challenge. One of the most common problems faced by all projects was the drawn-out bureaucratic process for accessing reliable scientific data from certain sources.

Many of these projects also deal with popular perceptions, and information from that field is challenging, not only to collect, but also to interpret. Perhaps an overarching theme is that many of these projects are pioneering, and therefore cannot build upon general knowledge. Furthermore, data and analysis, when available, is segregated into different disciplines, and not typically not usefully integrated. Data might exist on climate change and land use, for instance, but there is no analysis on how land use is affected or altered by climate change. In developing countries there is a growing need to build national and regional alliances to design reliable databases to deal with climate change challenges.

Although there is a growing awareness of, and many references to, climate change, much of these are based on media messaging, or highly complex models from the IPCC (DDC) and GCM models. The link between climate change information and adaptation practitioners on the ground remains largely nonexistent, and many adaptation practitioners in the agricultural sector, for example, still rely on generalized assumptions about how the climate will change, or have derived very general information about climate change and its impacts from IPCC reports, and are unaware of where to access more detailed data and how to interpret it (Ziervogel & Zermoglio 2009)[iv].

There is broad recognition that the ENSO varies widely naturally over the decades and centuries, making it difficult to understand how climate change affects its movements

Direct and indirect drivers of climate change have been identified by most of these projects. Most the projects agree that bio-physical stressors do not exist in isolation. Drivers are factors that directly or indirectly cause a change. The climate change literature has identified drivers in great detail, fully taking into account that climate change is accepted to be a man-made phenomenon. Therefore, drivers here are the increase in greenhouse gases and shifts in land use.

These projects do not always follow these directives when identifying drivers. Often there is a theoretical weakness where no distinction is made between drivers and effects, stressors, impacts, or even vulnerability factors. Certainly, this lack of clarity is generated by other challenges and difficulties, such as a lack of adequate data (an issue that affects research depth in these projects), as well as difficulties in identifying or demonstrating the links between perceived drivers and the impacts of human-induced climate change. For example, many projects show that sea level rise is just one climate change stressor, and data from different sources needs to be combined to build appropriate responses. In wetland areas, these projects have developed a methodological framework where various biophysical variables have been prioritized to look at climate change-related impacts. Even so, in a context where data - especially the complex comparison of comprehensive data and popular perceptions - is lacking, communities are still organizing tailored, nuanced responses to climate change.

The convergence of natural, recurrent physical processes such as El Niño (or ENSO) and other climate change drivers affecting the same ecosystem or community may require specifically tailored assessments and research to develop adaptation measures. This also occurs in large estuary systems such as the Amazon, where the main natural physical drivers of coastal processes, such as the volume of precipitation in river tributaries, seem critical to define the height of seasonal flooding and tidal regimes. There is broad recognition that the ENSO naturally varies widely over the decades and centuries, making it difficult to understand how climate change affects its movements. A reconstruction now shows that there has been abnormally intense activity in the late twentieth century, relative to the past seven centuries. This suggests a response to climate change, and will provide information to improve climate models and projections. Recent studies support the idea that the unusually high ENSO activity in the late 20th century is a footprint of global warming.[v] Combining data and methods by looking at drivers as pressuring large-scale natural processes such as the ENSO could generate new collaborations between data sets that could bring a range of relationships to light, and in turn help local communities develop complex adaptation plans.

Given the range of considerations involved in developing adaptation measures for climate change in coastal zones, our methods need to go well beyond much of the existing climate change literature, which focuses on greenhouse gases and land-use change. Our multi-method approach across our project sites, developed in partnership with local organizations and stakeholders, adds a nuanced set of tools, drawn from coastal zone research, to understand and adapt to a changing climate. This coastal zone research, combined with other area studies with a focus on other ecosystemic drivers, needs to be further integrated and made accessible to the widest possible range of people living with the complex effects of a rapidly changing climate.

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[i] IPCC Fourth Assessment Report: Climate Change 2007. Working Group I: The Physical Science Basis. FAQs 2.1 How do Human Activities Contribute to Climate Change and How do They Compare with Natural Influences?

[ii] IPCC WGII AR5 http://ipcc-wg2.gov/AR5/images/uploads/WGIIAR5-Chap25_FGDall.pdf

[iii] D.A Stainforth, M.R Allen, E.R Tredger and L.A Smith. Confidence, uncertainty and decision-support relevance in climate predictions. *Phil. Trans. R. Soc. A* vol. 365 no. 1857 2145-2161 (August 2007)

[iv] Ziervogel, G. and Zermoglio, F. (2009). Climate change scenarios and the development of adaptation strategies in Africa: challenges and Opportunities. Climate Research (40): 133 –146

[v] Jinbao Li, Shang-Ping Xie, Edward R. Cook, Mariano S. Morales, Duncan A. Christie, Nathaniel C. El Nino modulations over the past seven centuries. *Nature Climate Change* 3, 822–826 (2013)