United Nations Development Programme

UNDP

Mapping Climate Change Vulnerability and Impact Scenarios

A Guidebook for Sub-National Planners

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This guidebook is part of a series of publications UNDP is developing under the Territorial Approach to Climate Change (TACC) platform to provide guidance to regional governments on climate change planning. The series consists of a main publication, *A Primer on Integrated Climate Change Planning for Regional Governments*, which provides an overview on how to pursue low-emission climate-resilient development, and guidebooks like this one, that are topic specific and that outline a process that is important to achieving a low-emission future.

This guidebook was prepared under the technical oversight of Pradeep Kurukulasuriya and Stephen Gold, Environment and Energy Group, Bureau for Development Policy, UNDP, New York.

Authors

The guidebook was compiled by Katharine Vincent using contributions from experts on planning (at the national and sub-national level), economics, geography, engineering, systems modeling, and climate change science based in a number of countries (France, South Africa, Uganda, Ghana, Mauritius, and the USA). Alain Retiere, Violaine Lepousez, Serge Dedeystere and Benjamin Ponge (ClimSAT Brest, France) provided information on the Uruguayan case study that is reflected throughout the guidebook. Stephane Hallegate (Centre CIRED, France), Prakash (Sanju) Deenapanray (UNDP Country Office, Mauritius), and Pradeep Kurukulasuriya (UNDP, Environment and Energy Group) provided technical guidance and contributions to the substance that is reflected in the guidebook. Winfred Nelson of Ghana's National Development Planning Commission and Ondure Machulu Fred of the Planning Division of Uganda's Ministry of Foreign Affairs provided an important planners' perspective to the publication.

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Foreword

Climate change is a defining challenge of our time and it is one of the most pressing threats to development today. Scientists tell us that if immediate action is not taken to slow down and reverse the increase of greenhouse gas emissions, changes in our climate could have catastrophic consequences for the entire planet. Under these circumstances, the poorest and most vulnerable populations of the world would endure the harshest impacts and suffer disproportionately from the negative effects of climatic changes.

Addressing the possible impacts of climate change is entirely compatible with pursuing development. In fact, it is critical to achieving the Millennium Development Goals. Our experience at UNDP over the past two decades indicates that the right mix of policies, skills, and incentives can influence behaviour and encourage investments in climate-friendly activities. To achieve this, UNDP enhances the capacity of developing countries to formulate, finance and implement national and sub-national low-emission, climate-resilient plans that align climate management efforts with development goals, and promote synergies between development and climate finance.

A key planning tool to formulate low-emission, climate-resilient plans is the mapping of vulnerabilities to climate change. This is the topic of the present UNDP publication, *Mapping Climate Change Vulnerability and Impact Scenarios: A Guidebook for Sub-National Planners*, which aims to help sub-national planners identify and map current and future vulnerability to long-term climate change. This work builds on a large range of UNDP's ongoing initiatives to map climate change vulnerability and support climate change adaptation at the national and sub-national levels.

The present guidebook is part of a series of practical guidance documents and toolkits UNDP is developing to support national and sub-national governments on their preparation of low-emission, climate-resilient development strategies. It is UNDP's hope that this series of publications will empower sub-national planners to take action, and to prepare their territories to adapt, and hopefully thrive, under changing climatic conditions.

Yannick Glemarec
Director for Environmental Finance/UNDP-GEF Executive Coordinator
UNDP/BDP/EEG

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ACRONYMS

ALM	Adaptation Learning Mechanism
AOSIS	Alliance of Small Island States
AIACC	Assessments of Impacts and Adaptations to Climate Change
CBA	Cost Benefit Analysis
CBD	Capacity Building for the Development of Adaptation Measures in Pacific Countries
CBO	Community Based Organization
CSIRO	Commonwealth Scientific and Industrial Research Organization (Australia)
CRISTAL	Community-Based Risk Screening Tool – Adaptations and Livelihoods
CVCA	Community Vulnerability and Capacity Assessment (CARE handbook)
DEM	Digital Elevation Model
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
GCM	Global Climate Model
GDP	Gross Domestic Product
GEF	Global Environment Facility
GHG	Greenhouse Gases
GIS	Geographic Information System
GPS	Global Positioning System
IDS	Institute of Development Studies
IGSM	Global System Model Version 2
IIED	International Institute for Environment and Development
IISD	International Institute for Sustainable Development
INGC	National Disaster Management Institute (Mozambique) (Instituto Nacional de Gestão de Calamides)
IPCC	Intergovernmental Panel on Climate Change
IRI	International Research Institute for Climate and Society
ITCP	Integrated Territorial Climate Plan
IUCN	World Conservation Union
LCA	Linking Climate Adaptation Network
LDC	Least Developed Country
NAPA	National Adaptation Programme of Action
NCAR	National Center for Atmospheric Research (USA)
NGO	Non-Governmental Organization
PBB	Programme Based Budgeting
PICCAP	Pacific Island Climate Change Assistance Programme
PM	Prime Minister
PNW	Pacific Northwest (USA)
RCM	Regional Climate Model
SCCF	Special Climate Change Fund
SEI	Stockholm Environment Institute
SLR	Sea Level Rise
SRES	Special Report on Emissions Scenarios
SWMM	Storm Water Management Model
TACC	Territorial Approach to Climate Change
UKCIP	United Kingdom Climate Impacts Programme
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNISDR	United Nations International Strategy for Disaster Reduction
VARG	Vulnerability and Adaptation Resource Group
WHO	World Health Organization
WMO	World Meteorological Organization

PART I

OVERVIEW

Chapter 1	The Role of Vulnerability Analysis in the Development of Low-Emission Climate-Resilient Strategies
Chapter 2	Institutional Mapping
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Chapter 1

The Role of Vulnerability Analysis in the Development of Low-Emission Climate-Resilient Strategies

> "Climate change vulnerability refers to the state of susceptibility to harm from exposure to climate hazards, and the ability of the sub-national territory (or other unit of analysis) to cope with, and recover from, such exposure as well as manage incremental and long-term change in climate."

"The implementation of the mitigation and adaptation policies necessary to successfully address the climate change challenge will only be achieved, and sustained, through involvement and commitment at all levels of decision-making. In particular, sub-national authorities (regions, provinces, states or municipalities) have a key role to play in actively incorporating climate change considerations in day-to-day business and in introducing climate-friendly policies, regulations and investment decisions at their level, as a direct outreach to the public. Adaptation to climate change is very site-dependent, and local planning decisions will be critical to tailor almost every single adaptation action to the conditions in which it will take place. Similarly, 50% to 80% of GHG emissions are influenced by local behavior and investment choices."(UNDP, 2009: 14)

1.1 Purpose of Guidebook

Climate change is a cross-cutting issue that is increasingly recognized as a necessary component of development-oriented decision-making and is being integrated into this process by planners. In order to support sub-national areas ("territories") to become resilient to anticipated climate change, it is important for the nature of vulnerability to be understood from a sub-national perspective and reflected in relevant development strategies that are formulated at various levels (local, sub-national and national). Climate change vulnerability refers to the state of susceptibility to harm from exposure to climate hazards, and the ability of the sub-national territory (or other unit of analysis) to cope with, and recover from, such exposure as well as manage incremental and long-term change in climate. The likelihood of exposure to anticipated and/or unexpected climate-induced hazards and perturbations is thus only one part of the equation. In addition, climate change vulnerability encompasses how much the sub-national territory (the environment, society, and economy) will be affected – in other words, how *sensitive* it is to the change. It also includes the territory's potential to cope with, recover, and adjust to the impacts of climate change, that is, its *adaptive capacity*. Identifying vulnerability is therefore a necessary prerequisite to developing low-emission climate-resilient plans and strategies, and to ensuring that societies are resilient in the face of climate change. Once vulnerability has been determined, it is often useful to map this information so that the likely location(s) of vulnerable sectors and people are identified for a range of likely possible climate futures. This information, in turn, can be used for multiple purposes, including advocacy as well as contributions towards investment decisions and prioritization of actions. This guidebook focuses on the various stages required in order to identify and map vulnerability. It is a contribution to the process of articulating a low-emission climate-resilient plan, and is one of a number of upcoming UNDP publications that aim to assist in this goal.

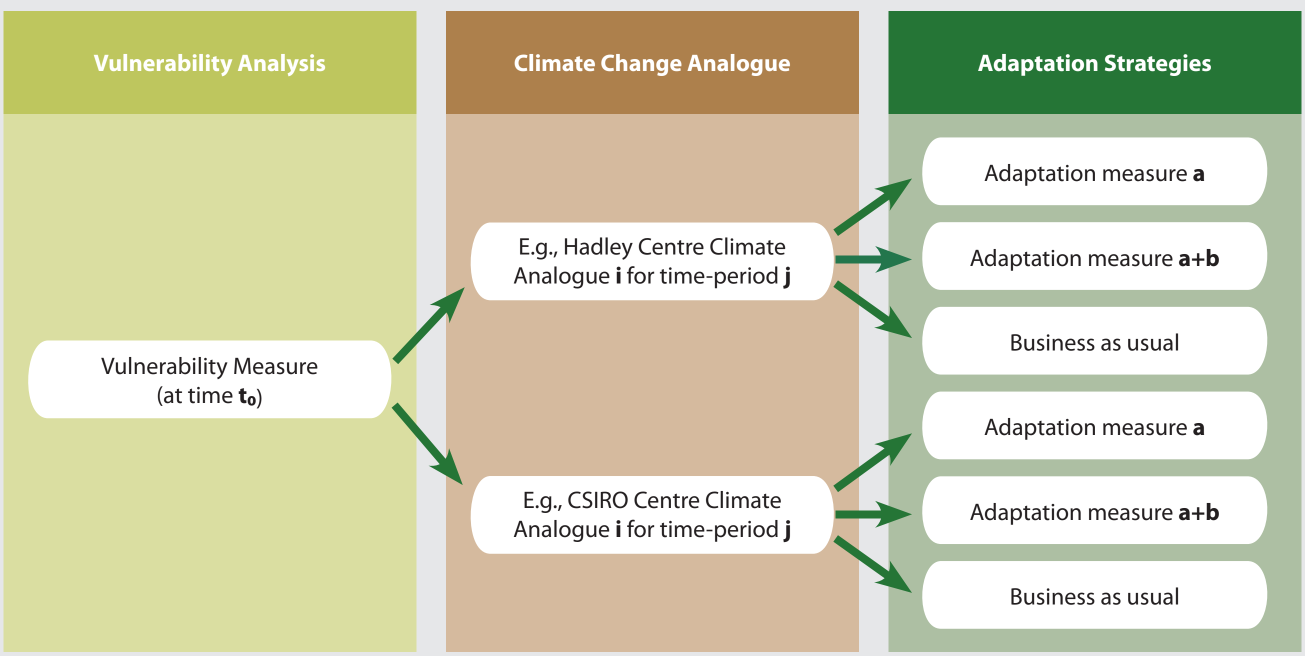
Addressing climate change is challenging for reasons relating to both the uncertainty of climate science and the uncertainty of how the environment and society will respond to the impacts of climate change

> “. The challenge for planners is to consider the range of scenarios of climate change (from the most conservative to the extremes) in their territories, and their resultant sectoral effects.”

over time. The interconnectivity of the global atmosphere and oceans, and the unknown nature of their feedbacks and interactions under change, make it very difficult to predict the exact manifestations of climate change from place to place in the future. At the same time, we do not yet know how the patterns of emissions from human activity will change in the future, which means that the risks from climate change are uncertain. There is sufficient information based on likely rates of growth and technology innovation and adoption to make intelligent projections of how change is most likely to manifest over time. There is scientific proof that the earth is already committed to changes in climate in the future that have been caused by historical greenhouse gas emissions. Existing international policy instruments to reduce those emissions (e.g., the Kyoto Protocol under the United Nations Framework Convention on Climate Change) will have negligible effects in the foreseeable future in terms of averting impacts that are already starting to manifest. These will only intensify over time. Climate change is expected to worsen existing vulnerabilities and create new ones. The question is to what degree will such change occur, and where?

From a planning perspective, climate change alters the decision-making environment through direct effects on many sectors: population, agriculture, water, energy, tourism, fisheries, health, and biodiversity. Thus, rather than being addressed as an issue in isolation, it needs to be mainstreamed within all these sectors. But the exact effects on each sector and over time will differ, and cannot be accurately predicted at present. The challenge for planners, therefore, is to consider the range of scenarios of climate change (from the most conservative to the extremes) in their territories, and their resultant sectoral effects. It will

Figure 1.1: Key Steps in Assessing Adaptation Options



Source: Kurukulasuriya et al. (2008) in Charting A New Low-Carbon Route to Development, UNDP, 2009 then be necessary to ensure that a combination of no regrets, low-cost and high-cost policies and measures are pursued, at the appropriate time, with the goal of promoting climate-resilient societies. Such responses must be robust to the range of likely scenarios of climate change and sectoral impacts, and also must consider a range of potential adaptation options to meet different needs over different time-scales. Figure 1.1 shows this schematically, with the light green column reflecting the need for vulnerability analysis (based on current climate), the brown column depicting the need to take into account various scenarios of climate change in order to determine likely impacts (with or without assuming autonomous adaptation), and the dark green column showing how a range of adaptation measures also needs to be considered to address these likely impacts through planned adaptation (with and without assuming autonomous adaptation).

1.2 Target Audience/Users of the Guidebook

This guidebook was written with the intention of assisting planners working at the sub-national level. It is assumed that the audience may have little or no prior knowledge of climate change, but needs to understand how to identify and map the nature of current and future vulnerability to long-term climate change so that appropriate policies and interventions can be designed and implemented.

It is our intention that this guidebook will be a useful reference for planners as they grapple with climate change and the need to assess the potential vulnerability of various sectors within their sub-national territory. It is intended to complement other technical guidance documents UNDP has developed to support countries in developing low-emission climate-resilient development strategies such as Integrated Territorial Climate Plans (ITCPs). The guidebook is written in non-technical language and is process-based. It presents the various sequential stages that are required to identify hazards and perturbations, sensitivity and adaptive capacity in a given place – which interact to make up location-specific vulnerability. Different stages in the process are accompanied by suggestions of sources of further information on how to implement the guidance provided, and advice on various stakeholders to consult. It is our hope that this guidebook will serve as a support tool to guide relevant sub-national level officers through the process of vulnerability identification and mapping.

Box 1.1: Need for Sub-National Level Vulnerability Mapping in Uruguay

In Uruguay, as in many countries, few policy-makers and stakeholders are aware of the magnitude of anticipated economic impacts of climate change. As a result, the issue has not been a priority. This trend is changing and countries are beginning to place more importance on climate change and its potential impacts. Availability and access to information, however, lags behind the sense of urgency to assess vulnerability and develop response measures. Even existing processes, like the National Communication to the United Nations Framework Convention on Climate Change (UNFCCC), still do not adequately address or estimate the anticipated economic impacts of climate change. Discussion on how to pursue low-carbon development within the context of climate change is missing.

There are other opportunities in Uruguay to gather information necessary for vulnerability mapping that are either being missed at the local level or not fully being utilized. These include important linkages to disaster risk response and management initiatives led by Sistema Nacional de Emergencias. If created, these could be used as a basis for establishing early warning systems, assessing vulnerability, and building capacity.

DEFINITION

Climate-resilient society

A society that has taken the following measures to adapt and respond to climate change:

- Assess vulnerability to climate change
- Assess greenhouse gas emissions
- Identify opportunities in relation to climate investment and low-carbon energy options
- Define priority mitigation and adaptation measures

“Climate change is expected to negate decades of progress and undermine the hard-won development gains made in many regions of the world.”

Table 1.1: Impacts of Climate Change in Economic Terms

Estimates of the Impacts of Climate Change (in economic terms)	Source
Estimates suggest climate impacts equal to 2% of Gross Domestic Product (GDP) this century.	Pearce, 1996
Estimates range from nearly zero impact to almost 40% of world GDP. Modern estimates take into account adaptation, benefits of warming, and shrinking of climate sensitive economic sectors.	Downing et al., 1996a, b
Estimates suggest values closer to 0.2% to 0.5% of GDP this century.	Tol, 2002 and Mendelssohn and Williams, 2004
Estimates show 5% losses in global GDP every year until 2200.	Stern, 2006
Estimates indicate that over the next 25-50 years market impacts in Africa on the agriculture sector will be on the order of losses of $22 billion per year (by 2020) and $47 billion (by 2100) under scenarios of more than 3°C warming.	Kurukulasuriya and Mendelssohn, 2008

1.3 Impacts of Climate Change

Climate change is expected to negate decades of progress and undermine the hard-won development gains made in many regions of the world. According to the latest Intergovernmental Panel on Climate Change (IPCC) findings, the world is already facing an inevitable increase in average temperatures by 0.5°C to 1°C until approximately 2035, after which positive change will accelerate and approach a 2°C increase (relative to 1990 levels) by 2050. Natural variability, namely that which occurs regardless of human activity, may act to dampen or amplify these projected changes. The consequent biophysical and socio-economic changes that are expected are varied and are, in part, contingent on the type, frequency, intensity, duration and distribution of climate-induced hazards that can be expected even under relatively modest scenarios of climate change. According to the recent Stern Review (Stern, 2006), a warming of 2°C is likely to result in the extinction of 15-40% of all species, a 3°C or 4°C change in temperature will result in millions of people being displaced due to flooding, while a warming of 4°C or more is likely to seriously affect global food production. Table 1.2 and Figure 1.2 outline examples of major projected impacts by sector. However, although national level impacts of climate change have been projected, there is much less consideration of the local level (Box 1.1).

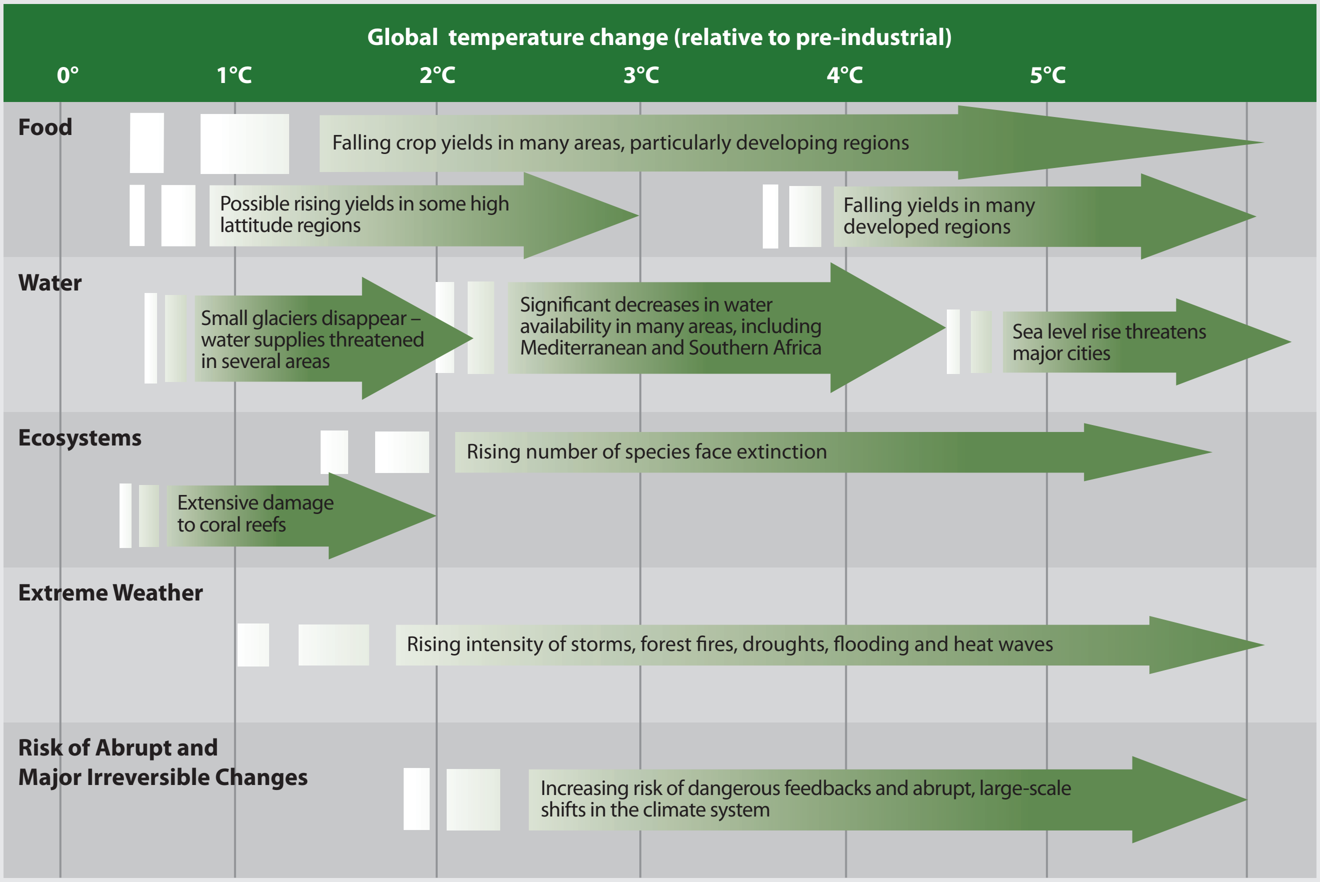
There have been numerous efforts to quantify the impacts of climate change in economic terms. Table 1.1 above provides an overview of some of these efforts.

Table 1.2: Summary of Projected Major Impacts by Sector due to Changes in Climate and Extreme Weather Events over the 21st Century (not taking into account adaptive capacity)

Phenomenon and Direction of Trend	Likelihood of Future Trends based on Projections for 21st Century using Special Report on Emissions Scenarios (SRES) Scenarios	Examples of Major Projected Phenomenon Impacts by Sector			
		Agriculture, Forestry and Ecosystems	Water Resources	Human Health	Industry, Settlement and Society
Over most land areas, warmer and fewer cold days and nights, warmer and more frequent hot days and nights	Virtually certain	Increased yields in colder environments; decreased yields in warmer environments; increased insect outbreaks	Effects on water re- sources relying on snowmelt; effects on some water supplies	Reduced human mortality from decreased cold hazards	Reduced energy demand for heating; increased demand for cooling; declining air quality in cities; reduced disruption to transport due to snow, ice; effects on winter tourism
Warm spells/heat waves; frequency increases over most land areas	Very likely	Reduced yields in warmer regions due to heat stress; increased danger of wildfire	Increased water demand; water quality problems, e.g. algal blooms	Increased risk of heat-related mortality, especially for the elderly, chronically sick, very young and socially isolated	Reduction in quality of life for people in warm areas without appropriate housing; impacts on the elderly, very young and poor
Heavy precipitation events; frequency increases over most areas	Very likely	Damage to crops; soil erosion; inability to cultivate land due to water logging of soils	Adverse effects on quality of surface and groundwater; contamination of water supply; water scarcity may be relieved	Increased risk of deaths, injuries and infectious, respiratory and skin diseases	Disruption of settlements, commerce, transport and societies due to flooding; pressures on urban and rural infrastructures; loss of property
Area affected by drought increases	Likely	Land degradation; lower yields/crop damage and failure; increased livestock deaths; increased risk of wildfire	More widespread water stress	Increased risk of food and water shortage; increased risk of malnutrition; increased risk of water-and food-borne diseases	Water shortage for settlements, industry and societies; reduced hydropower generation potentials; potential for population migration
Intense tropical cyclone activity increases	Likely	Damage to crops; wind throw (uprooting) of trees; damage to coral reefs	Power outages causing disruption of public water supply	Increased risk of deaths, injuries, water- and food-borne diseases; post-traumatic stress disorders	Disruption by flood and high winds; withdrawal of risk coverage in vulner-able areas by private insurers, potential for population migra-tions, loss of property
Increased incidence of extreme high sea level (excludes tsunamis)	Likely	Salinization of irrigation water, estuaries and freshwater systems	Decreased freshwater availability due to saltwater intrusion	Increased risk of deaths and injuries by drowning in floods; migration-related health effects	Costs of coastal protection versus costs of land-use relocation; potential for movement of populations and infrastructure

Source: IPCC, 2007

Figure 1.2: Potential Impacts Depending on the Degree of Climate Change



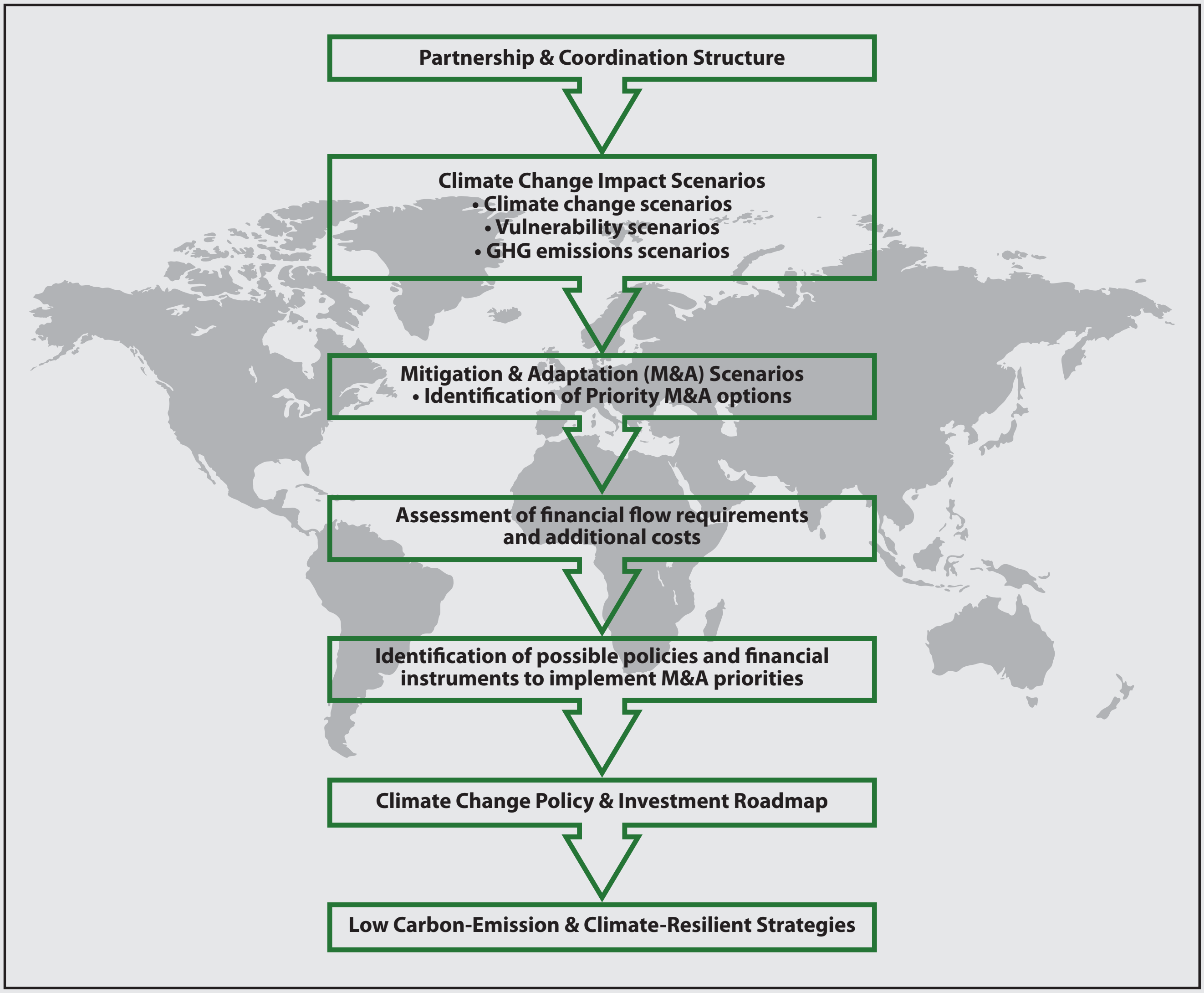
Source: Stern, 2006

1.4 UNDP's Territorial Approach to Climate Change

This guidebook is part of the UNDP-led initiative: "Down to Earth: Territorial Approach to Climate Change" (Figure 1.3). The objective of this new environmental finance service platform is to assist regional and local governments in developing countries in:

- Developing integrated climate change strategies and action plans to assess development options that are robust to a range of future long-term climate change conditions.
- Strengthening capacity for sub-national authorities to integrate climate change into area-based (sub-national) planning and programming.
- Identifying no regrets/negative costs/low cost adaptation and mitigation measures that promote long term sustainability and complement ongoing poverty reduction efforts.
- Enhancing the capacity of regional and local governments to identify and enact appropriate regulatory measures, to take advantage of new sources of environmental finance and to implement these no regrets/negative cost/low cost initiatives.

Figure 1.3: UNDP's Territorial Approach to Climate Change



Source: UNDP

Estimates of the impacts of climate change, such as those provided in Table 1.1, are the result of a range of complex types of vulnerability assessments. Such types of assessments involve an integrated consideration of climate change scenarios, projections of anticipated biophysical changes in part driven by climate change itself, in part driven by other anticipated and non-anticipated factors (e.g., land use change due to management practices), projected socio-economic changes, and a host of other factors. The assessments also typically include the application of cutting-edge techniques in the economic valuation of market and non-market impacts.

While readers should be aware of the various levels of uncertainty that are associated with such types of results, including uncertainty in the science, statistical concerns, limitations in modeling frameworks and

> "The estimates are a necessary step for defining and setting up appropriate enabling environments, consisting of robust policies and appropriately capacitated institutions to promote low-emission climate-resilient development. These can then work to reduce the costs (or maximize opportunities) associated with a changing and uncertain climate future and protect vulnerable groups from new climate change driven pressures."

approaches, these estimates provide useful insights into the magnitude and scale of the underlying climate change problem. They are helpful reference points for addressing the competing impacts and issues with which most countries grapple on a frequent basis. The estimates are a necessary step for defining and setting up appropriate enabling environments, consisting of robust policies and appropriately capacitated institutions to promote low-emission climate-resilient development. These can then work to reduce the costs (or maximize opportunities) associated with a changing and uncertain climate future and protect vulnerable groups from new climate change driven pressures.

In this context, this publication is part of a series of toolkits that will support sub-national authorities (regions and cities) in developing countries to build internal capacity to design and implement climate change strategies and investment plans. This specific guidebook provides advice on preparing and mapping vulnerability assessments of climate change impacts at a sub-national level. As demonstrated by Figure 1.3, this is one of a number of key components that at a minimum need to be completed in order for a robust low-emission climate-resilient strategy to be developed. In addition to assessing vulnerability, other components include: raising awareness about climate change; assessing greenhouse gas emissions; identifying opportunities in relation to climate investments and low-carbon energy options; and defining priority mitigation and adaptation measures.

1.5 Structure

The guidebook is structured in four parts and five chapters. Part I, containing this introduction, provides an overview of the guidebook, including its purpose and intended audience. It sets the context and introduces institutional mapping, discusses planning perspectives and timeframes and elaborates on the need for stakeholder involvement and participatory mechanisms to make the process more robust. It also introduces the concept of vulnerability: what it encompasses, what the driving forces are, and how to measure it, including the types and sources of data that are required. It introduces vulnerability as a function of exposure to climate hazards and perturbations, sensitivity to those hazards and perturbations, and the adaptive capacity of society.

Part II forms the main focus of the guidebook. Chapter 4 provides step-by-step advice on the procedures to follow in order to assess each of the components that make up vulnerability. It also provides guidance on how to integrate and map the results. Step 1 looks at determining and projecting hazards and sensitivity to climate change, by evaluating meteorological data and both climate and socio-economic model outputs, taking into account various scenarios. Step 2 elaborates on how to assess and project adaptive capacity, suggesting a more qualitative approach that relies on expert input. Step 3 then focuses on how to integrate the results of Steps 1 and 2, leading to the production of alternative maps of vulnerability to climate change (based on present conditions and various scenarios of future projected changes) for use in sub-national planning.

Since identifying and mapping vulnerability is just one part of the larger process of developing climate-resilient sub-national territories, Part II also suggests some of the applications of these outputs and next steps, and provides linkages between this guidebook and other toolkits for sub-national planners developed within UNDP's Territorial Approach to Climate Change. Step 4 shows how vulnerability maps are necessary prerequisites for the more normative and politicized subsequent decision-making processes that are required to prioritize vulnerabilities within the sub-national territory and identify appropriate adaptation responses.

Part III, Chapter 5, summarizes the guidebook, and Part IV serves as a resource section with a glossary of terms and list of relevant websites.

Chapter 2
Institutional Mapping

2.1 Introduction

As discussed in Chapter 1, planning for climate-resilient societies is not a singular event, meaning it is not the preserve of any one institution or sector nor is it a one-time or infrequent analytical exercise. Given the nature of climate change and our rapidly evolving understanding of how to better analyze its implications on key sectors, a more organic and dynamic approach is necessary. Planning must be fluid in nature, as both our understanding of vulnerabilities to the impacts of climate change becomes clearer, and as tools and methodologies are designed for dealing with the inherent uncertainties associated with the planning process and climate change itself. Although the primary target audience of the guidebook is sub-national planners, it is important to note that:

- The process of mapping vulnerabilities does not necessarily have to be carried out at the sub-national level, in order to generate valuable information to assist decision-making at the sub-national level;
- There may be institutional and legal frameworks in place that disempower planners to carry out planning related to climate change at the sub-national level; and
- In circumstances where sub-national planners are able to carry out the mapping exercise, they will need to work in close collaboration with a multitude of stakeholders to generate the vulnerability maps and make use of these maps to effect planned changes. Stakeholders include local scientists and researchers, private sector technical staff, international organization technical staff, and relevant sectoral departments in local authorities. For an example in Uruguay, see Box 2.3.

Another important factor to consider, which is generic to any planning process related to addressing climate change decisively, is the disparity that exists between the political time frame within which policy decision making takes place, and the time frame over which the impacts of climate change manifest. In addition, one must factor in the different time frames that are associated with various planned actions to adapt to climate change (or to embark on a low-carbon development path) such as changing human behavior (in terms of both Human & Social Capital), building infrastructure (Built & Technological Capital), or investments to enhance the ecosystem functions and services (Natural Capital) (see Figure 2.3).

These institutional factors are discussed in more detail in the remainder of this chapter so that the sub-national planners are better able to map out the relevant framework within which they are operating. In this way, the planners may be better equipped to either address the additional uncertainties generated by the institutional set up or to capitalize on the opportunities that it offers to tackle developmental issues related to climate change at the sub-national level.

2.2 Planning Structures and Procedures

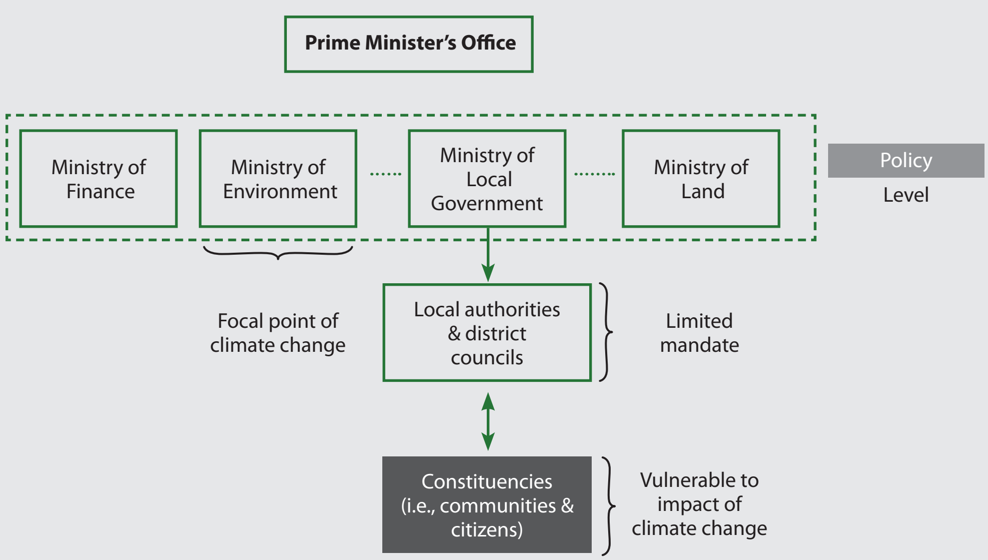
Sub-national planners operate in a context dependent on the institutional structures that determine how planning for adaptation to climate change can take place at the sub-national level. As shown in Figure 2.1, there are several issues to consider.

> "Planning must be fluid in nature, as our understanding of vulnerabilities to the impacts of climate change becomes clearer, and as tools and methodologies are designed for dealing with the inherent uncertainties associated with the planning process and climate change itself."

Figure 2.1 helps to identify certain potential barriers that need to be addressed and/or to identify the levers to pull to effect positive change. Since institutional structures and planning procedures differ from country to country (and sometimes even between regions within a country), it is left to the sub-national planners to identify the constraints and opportunities offered by the system in which they are operating. The following should serve as guidelines only:

- Sub-national planners operate at the level of local authorities (municipality, district, county, province) that form an important link between the central authority (ministry, departments and the like) and the communities that are impacted by climate change. In this configuration, the sub-national planners will have to gauge the extent to which they can act autonomously, as well as collectively, on issues related to adaptation to climate change (see Figure 2.1).
- Typically (although not always), local authorities in developing countries act under the aegis of the Ministry of Local Government (or similar entity) which is responsible for policy formulation regarding development issues at the sub-national level. This would depend on the level of centralization/decentralization prevailing in the country. Hence, it cannot be taken for granted that the locus of control of local authorities is sufficiently broad to influence policy related to climate change or low-carbon development. In any case, this is the level at which sub-national planners are most well placed to intervene.

Figure 2.1: Institutional Structure Within which Sub-National Planners Have to Operate



Source: Deenapanray and Ondure Machulu, 2009

Box 2.1: The Uneasy Fit of Climate Change within the Institutional Architecture in Developing Countries

The long timeframe considerations required for climate change, and the uncertainty, make for an uneasy fit with planning processes and structures. Currently available tools have typically focused on short-term threats in two or three key sectors with less emphasis on resilience of long-term investment in the context of climate uncertainty. At the national level, National Communications to the UNFCCC have endeavored to lay the foundation for prospective exercises to address climate risks. However, this has been hampered by the lack of relevant analysis and capacities to inform policy. In addition, current tools focus exclusively on climate, economics, or engineering and do not look at the issues in an integrated way. Technical capacity, leadership and/or relevant institutional structures, including budgetary support to sustain the application of appropriate planning tools, are often lacking.

- Local authorities usually operate under an Act of Parliament (or similar equivalent) that sets out their mandate. If the Act of Parliament was promulgated several decades ago (which is most probable), then it may well be that dealing with the impacts of climate change is outside the mandate of local authorities, unless those impacts coincide with their existing mandates. For instance, local authorities in Mauritius have the mandate to maintain secondary drains – a task that now has more importance because of the frequent occurrences of flash flooding. However, there are a host of activities such as the design, construction and maintenance of primary drains, and urban land design, that are outside their mandate.
- Sub-national planners may also need to face the institutional mind-set that climate change is an "environmental" issue, and as such should be dealt with primarily by the Ministry of Environment or the Meteorological Services (one of which is also likely to be the national focal point for climate change to the UNFCCC). If issues related to climate change are dealt with centrally by the National Climate Change Committee the locus of control of sub-national planners may become even more diluted.

2.3 Dealing with the Uncertain Environment of Having to Work with Other Planners - both Horizontally and Vertically

Over and above the uncertainties inherent to the science of climate change and the time scale and magnitude of its various manifestations, the elements discussed in the previous section add further uncertainties regarding the ability of planners to address the impacts of climate change at the sub-national level. Even in circumstances when the sub-national planners have the full mandate to map out vulnerabilities to the impacts of climate change and articulate planned adaptation measures, a few points need to be highlighted concerning the extent (and implications) of collaborative action required with other stakeholders.

- Climate change cuts across a multitude of disciplines, while its impacts affect all sectors (environment, society and economy). This requires the sub-national planners to work in close collaboration with other planners both horizontally and vertically.
- Sub-national planners will have to be astute in identifying the key stakeholders that are required either to inform the process of mapping of vulnerabilities to impacts of climate change (where the sub-national planners have the mandate to do so), or to carry out analyses using the vulnerability maps to

> "It is precisely because of the availability of limited resources for allocation towards alternative development goals that no regrets/low regrets solutions to adaptation to climate change are promoted."

generate information that can be used to guide the planners to make informed decisions (in situations where the planners are not empowered to carry out the vulnerability mapping exercise). The need for stakeholder consultation is discussed in section 2.5.

- Sub-national planners will have to engage with other planners who operate at the central and community levels, as well as in different sectors of the economy. The different planners may have different conceptions and conceptualizations of climate change and its impacts, including from an ethical perspective. The different planners may also operate on different time scales that will reflect how uncertainties are accounted for, and prioritization in allocation of scarce resources. It is precisely because of the limited resources available for allocation towards alternative development goals that no regrets/low regrets solutions to adaptation to climate change are promoted. The need to reconcile the timescale and planning horizons of different planners is discussed in section 2.4.

2.4 Timescales for Decision-Making

The sub-national planners working on vulnerability mapping must be aware of any tensions that may arise from the different time perspectives that are offered by the shorter political and policy cycles, planning horizons that may extend up to 2-3 decades, and different life cycles of planned adaptation measures on the one hand, and the time scale over which impacts of climate change can be felt. The differences are illustrated in Figure 2.2 and Figure 2.3.

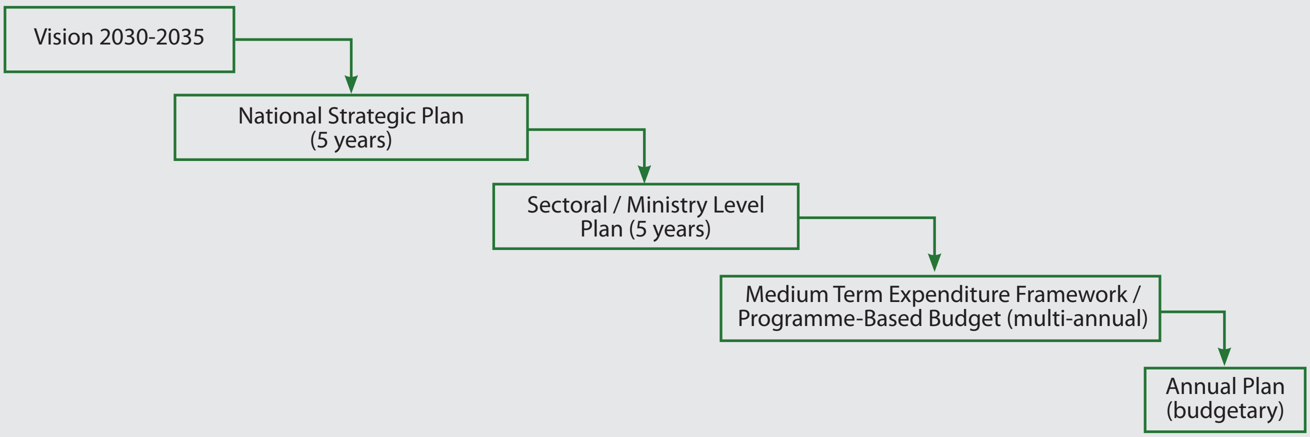
The political time frame coincides with the election cycle (e.g., 3-5 years), which characterizes the typical decision-making time frame used by most governments. The policy horizon is related to the period of time over which a particular policy will be implemented, and it is typically shorter than the planning horizon (e.g., Vision 2030-2035 in Figure 2.2). The policy horizon may coincide with the political time scale, but it can also be longer (e.g., up to 10 years). While national strategic plans and sectoral/ministry level plans may both last for 5 years, these 5 years may not always coincide.

There may also be disparities between the planning horizons of different stakeholders working on the same sector, such as water. A financial planner will probably work on a year-to-year budgetary cycle (at most on a multi-annual budgetary cycle within the election cycle). A planner dealing with water supply issues will work over a 5-15 year time span, whereas the engineering horizon for water storage infrastructure will be over 50 years. Similarly, enhancing or restoring ecosystem services as part of a watershed management strategy would be on a time scale exceeding 50 years. When dealing with climate change, the 'near-term' is generally taken as 2050. This opens up a completely different time scale to what is generally understood as near-term in political terms (e.g., up to 5 years).

In order to reconcile planning activities that span different time scales, it is important to carry out the mapping of vulnerabilities to the impacts of climate change over at least two time horizons, such as 2020 and 2050. This approach brings a balance between incremental planning to adapt to impacts of climate change that allow for current uncertainties related to the impacts of climate change to be addressed, without compromising longer-term outcomes (e.g., sea level rise), and (almost) immediate adaptation measures to anticipate irreversible climatic changes and their impacts on human well-being (e.g., loss of biodiversity). Box 2.2 summarizes reasons for planners to integrate consideration of climate change into their decision-making.

"In order to reconcile planning activities that span different time scales, it is important to carry out the mapping of vulnerabilities to the impacts of climate change over at least two time horizons, such as 2020 and 2050. This approach brings a balance between incremental planning to adapt to impacts of climate change that allow for current uncertainties related to the impacts of climate change to be addressed, without compromising longer-term outcomes (e.g., sea level rise), and (almost) immediate adaptation measures to anticipate irreversible climatic changes and their impacts on human well-being (e.g., loss of biodiversity)."

Figure 2.2: Schema Illustrating a Typical Planning Framework Employed by National Authorities



Source: Deenapanray and Ondure Machulu, 2009

Figure 2.3: Time Horizons Corresponding to Decision Making about Different Activities

Source: Jones and Mearns, 2004

DEFINITIONS

Stakeholders

Those who have interests in a particular decision, either as individuals or as representatives of a group. This includes people who can influence a decision as well as those affected by it. Decision-makers are also stakeholders.

External Stakeholders

This group may consist of local scientists and researchers, civil society groups, grassroots movements, industry and business groups, and citizens/traditional and opinion leaders. The broad variety of stakeholders within each group reflects the transdisciplinarity of climate change and its cross-sectoral impacts.

Internal Stakeholders

A wide variety of government representatives are likely to have relevant input to a vulnerability mapping process. They include those concerned with sectors directly affected by climate change, such as agriculture, coasts, water resources, forestry, fisheries, health, industry, biodiversity, parks and recreation, and land use zoning. As well as those working at sub-national level, it may also be appropriate to include planners working at national level, since many national level decisions affect the decision-making environment at the sub-national level.

Box 2.2: Summary of Reasons for Sub-National Planners to Integrate Climate Change

- **Climate change is already in motion.** The scientific community, through the IPCC, states unequivocally that climate change is happening. Communities around the world are beginning to see its effects.
- **Greenhouse gas emissions are unlikely to stabilize or reverse in the near future.** While there are increasing commitments both at global level through the UNFCCC and at the national level to reduce greenhouse gas emissions and follow paths of low-emission development, avoiding the worst climate change impacts requires greenhouse gas emissions to be reduced to the extent that atmospheric levels stabilize, and then decline. The magnitude of reductions required to reach this point will not be achieved soon.
- **Climate change may also create economic opportunities.** Despite the range of largely negative economic consequences associated with climate change, impacts on agriculture, fisheries, forests, water supply, health, energy, coastal development, transportation, recreation and tourism may create opportunities, particularly at the sub-national level. Increasing awareness of these opportunities and planning to take advantage of them are likely to increase the potential benefits to society.
- **Preparation is more effective and less costly than reacting to climate change as it occurs.** In assessing the future impacts of climate change, sub-national territories will be able to identify the vulnerabilities and risks and prioritize them according to development plans; this can reduce the potential adverse impacts of climate change (and need for reactive responses) and reduce the associated costs.
- **Adaptation and mitigation sometimes use the same tools and therefore have to be designed in parallel.** For example, where urban plans are modified to reduce future greenhouse gas emissions they should also take into account the way in which the modifications will influence vulnerability to climate change. Also, where risk reduction strategies are implemented, the subsequent changes in emissions and energy consumption have to be included in the analysis.
- **Preparing for climate change is good government.** Since climate change will affect such a wide range of sub-national sectors and services, anticipating changes and preparing for them is essential for maintaining the integrity of essential public services and facilities.

2.5 Stakeholders and the Need for Consultation/Engagement

The sub-national planners will have to interact with a multitude of stakeholders both during the mapping of vulnerabilities exercise and at the point of using the information generated by the mapping exercise. The purpose of the interaction is to inform decision-making regarding adaptation to climate change. The inclusion of stakeholders in planning processes leads to more robust (and legitimate) outcomes, by allowing the recognition and integration of alternative forms of knowledge into the processes, and by getting crucial support and buy-in for policy planning and project implementation. The process of identifying local stakeholders and highlighting their potential contributions to the process of mapping vulnerability to climate change is discussed in Box 2.3.

2.5.1 Definition and Identification of Stakeholders

Stakeholders are any people or groups of people that have an interest in a process, and given the broad nature of climate change, there are many stakeholders who need to be included in identifying and mapping vulnerability. From the planners' perspective, stakeholders are likely to fall into two categories: external and internal. This categorization does not imply that some stakeholders are more important than others. Rather, it is a simple methodology to assist planners in identifying stakeholders. External stakeholders are those situated outside the government structure, while internal stakeholders are those within

Box 2.3: Identification of Stakeholders in Uruguay

In 2007-08, UNDP supported Uruguay in a process of mapping vulnerability to climate change at the sub-national level. The process of vulnerability mapping in the metropolitan area of Montevideo involved the City's three municipalities and their coordinating structure, comprised of the *Programa Agenda Metropolitana*, the Climate Change Unit of the Ministry of the Environment, the Planning Office, UNDP, and ClimSAT (a UNDP/Government of France climate modeling service provider).

- Consultations took place with **stakeholders in sub-national level** departments that are concerned with hydrology, topography, water resource management, planning, natural resources management, fishing, meteorology and tourism; and also with public bodies that oversee administration of public infrastructure, including roads, railways, electricity, aviation and universities.
- Consultations were also held with **staff in existing projects and programmes concerned with climate change** such as the government sponsored early warning system, environment and poverty initiatives, vulnerability and sustainable environment at the territorial level, and *Ecoplata* and *Freplata*.
- **Climate change experts at the national level** within the Climate Change Unit (*Unidad de Cambio Climático*) of the Ministry of Environment or scattered in key ministries, such as Agriculture, were also consulted.
- Others—**academics and civil society representatives.**

“Stakeholders are any people or groups of people that have an interest in a process, and given the broad nature of climate change, there are many stakeholders who need to be included in identifying and mapping vulnerability.”

Box 2.4: Example of Stakeholder Engagement in a Climate Adaptation Project in Zambia

The Government of Zambia, with the support of UNDP and funding from the UNFCCC Least Developed Country Fund, recently designed a 4-year initiative called "Adaptation to the effects of drought and climate change in agro-ecological regions I and II in Zambia." The project aims to incorporate consideration of climate change into decision-making at a variety of scales from policy-makers at the national level down to farmers at the grassroots level.

As part of the design of this initiative, extensive stakeholder consultation took place, including five workshops and numerous meetings with various stakeholders. As a result of this process, the project proposal lists the roles and responsibilities of various stakeholders. This list provides clarity to the process and serves as a checklist to ensure that all relevant stakeholder groups are accounted for and have clearly defined roles and responsibilities.

The stakeholder organizations identified and given roles and responsibilities include:

- Ministry of Agriculture and Cooperatives
- Department of Agriculture
- Department of Policy and Planning
- Department of Veterinary and Livestock Management
- Department of Fisheries
- Zambia Agricultural Research Institute
- National Agricultural Information Services
- Ministry of Energy and Water Development
- Ministry of Communication and Transport
- Office of the Vice President (Disaster Management and Mitigation Unit)
- Ministry of Tourism, Environment and Natural Resources
- United Nations Development Programme Country Office
- Local communities/community-based organizations non-governmental organizations

the government structure. The keys to successfully conducting stakeholder meetings and consultations are beyond the scope of this guidebook, but wherever applicable or practicable, planners are provided with a list of useful materials and links for reference.

Table 2.1: Summary of Potential Stakeholders

Potential Participants in a Multi-Stakeholder Advisory Team	
External Stakeholders	
Local scientists/researchers	Civil society groups
Industry and business groups	Citizens/traditional leaders
Internal Stakeholders	
Agriculture	Coasts (including port and harbor management)
Water resources (including water supply and storm/ floodwater control)	Fisheries
Health	Biodiversity
Parks and recreation	Land use zoning
Disaster management/emergency preparedness	Surveying
Energy	Transport infrastructure
Buildings and urban infrastructure	Safety and health regulations
Heads of sub-national regions	Parliamentarians

Source: Based on Snover et al., 2007

“It is worth considering forming a multi-stakeholder advisory team at an early stage, since vulnerability mapping is likely to be the first step in a longer process that involves the design and ultimately implementation of an adaptation plan.”

2.5.2 Forming a Multi-Stakeholder Team

It is worth considering forming a multi-stakeholder advisory team – or climate change preparedness team – at an early stage, since vulnerability mapping is likely to be the first step in a longer process that involves the design and ultimately implementation of an adaptation plan. The exact composition of the team will vary, depending on the identification of relevant stakeholders (see Table 2.1). In order to keep the team manageable, it is advisable to keep it as small but representative as possible. Once the team has been established it will be necessary to decide upon a leader and consider operational modalities, including frequency, timing and location of meetings, and procedure for setting agenda items (Snover et al., 2007).

Additional Resources

Multi-Stakeholder Teams

For more ideas on forming multi-stakeholder teams, see Chapter 5, “Establishing a partnership framework for integrated climate change planning at the regional level”, in UNDP’s *Primer on Integrated Climate Change Planning for Regional Governments* (UNDP, 2009).

Chapter 3
The Three Components of Vulnerability

DEFINITIONS

Hazard

A physically defined source of potential harm, or a situation with a potential for causing harm, in terms of human injury; damage to health, property, the environment, and other things of value; or some combination of these (CARICOM, 2003).

Perturbations

Small variations from the norm in the physical system, typically of lesser magnitude than a hazard, but possibly of longer duration. Perturbations may retrospectively be identified as incremental change.

Sensitivity

The extent to which a unit of analysis reacts to stimuli. In climate terms, biomes, ecosystems, countries and sectors are all examples of units, which may have different levels of sensitivity when exposed to the same climate hazard (depending on the scale of the analysis).

3.1 Hazards and Perturbations

As the evidence for the existence of human-induced climate change is now clear, it is imperative that we understand what effects climate change will have on our environment and society. This is important so that strategies, plans, and measures to reduce adverse impacts – or capitalize on opportunities - can be designed and introduced appropriately. When we hear about climate change, it is normally in the sense of changing parameters that affect climate, and their corresponding consequences. The resulting phenomena might include an increase or decrease in rainfall, an increase in temperature or an increase in the incidence and intensity of extreme climate events, such as droughts and floods. Clearly the manifestation of climate change in terms of such hazards and perturbations will differ from place to place, depending on the geographical location. But still, while understanding how climate parameters in any location are likely to change is important, knowledge of the hazards and perturbations brought about by climate change is only one part of the picture.

3.2 Sensitivity

Different physical environments will respond in different ways, even if they are exposed to the same manifestation of climate change (whether a hazard or perturbation). An increase in temperature of 1˚C in the middle of a desert, for example, is likely to have less effect than a 1˚C increase in temperature on the margins of a desert or a semi-arid area. In the middle of a desert the increase might reduce the number of plant species that can grow, but on the margins of a desert or a semi-arid area, the same change is occurring at the margin of tolerance of certain species, and thus can lead to a change in species composition. The sensitivity of the physical environment to the hazards has knock-on effects for the human use of that environment, and it is important to note that these changes will not always be negative. So, for example, the exposure of eastern South Africa to an increase in rainfall, when much of the area is already semi-arid, could lead to an increase in crop productivity (if the distribution throughout the season is favorable to crop growth); whereas an increase in rainfall amount of similar quantity in an area that is already prone to flooding could cause problems. From the planner's perspective, different economic sectors – such as population, agriculture, water, energy, tourism, fisheries, health, and biodiversity – will all differ depending on their sensitivity to the hazards and perturbations to which they are exposed.

3.3 Adaptive Capacity

The impacts of climate change are a function of exposure to hazards and perturbations and sensitivity of the affected environment. They are also mediated by the human characteristics of the society in which they occur. The adaptive capacity of society is correlated with various social factors, including gender, ethnicity, religion, class and age. Together these social factors tend to give rise to differences in human capital (such as levels of education and status of health), financial capital (wealth) and access to governance and institutions, which in turn affect ability to anticipate, cope with, and respond to change). Since these all vary on the micro scale, this is particularly important when working at sub-national level. It may be the case, for example, that an entire sub-region will be exposed to the same climate parameter or hazard, such as a cyclone. The physical environment in the sub-region may be such that its sensitivity is similar across the whole area – for example in the case of a coastal location. But even so, the cyclone is likely to affect different members of the sub-region in different ways, depending on their adaptive capacity. Comparing the impacts of a cyclone in Southeast Asia with one of a similar magnitude that hits the southern USA, for example, highlights how adaptive capacity can differ.

Therefore:

vulnerability =
exposure to climate hazards and perturbations x sensitivity – adaptive capacity

In order to undertake a vulnerability assessment for a sub-national region, recognition and understanding of these three components of vulnerability is required. To determine and map the vulnerability of any sub-national territory, a series of questions must therefore be asked in turn (see Box 3.1).

The next chapter of this guidebook provides step-by-step guidance for addressing each of these questions, pointing to various sources of information that exist, potential stakeholders to consult and include in the process, and methods for analysis so that vulnerability maps can be produced.

DEFINITIONS

Adaptation

Adjustment in natural or human systems in response to actual or expected climate changes or their impacts, so as to reduce harm or exploit beneficial opportunities.

Adaptive Capacity

The potential or capability of a system to adjust its characteristics or behavior to anticipate, cope with and respond to climate variability and change.

Box 3.1: Questions to Determine and Map Vulnerability at the Sub-National Level

1. What are the projected hazards and perturbations under climate change?

- What is likely to happen to temperature patterns (average and variance) in the future?
- What is likely to happen to rainfall events (average and variance) in the future?
- Are extreme events (such as droughts, floods, or cyclones) likely to increase in frequency and/or magnitude?
- What is likely to happen to sea level?

2. What is the sensitivity to the projected hazards and perturbations?

- How will existing sectors of society (population, agriculture, water, energy, tourism, fisheries, health, and biodiversity) be affected by these hazards and perturbations?
- Are there current socio-economic trends that interact with these sensitivities (and in particular run the risk of amplifying them)?

3. What is the level of adaptive capacity?

- How will society be able to cope with and manage these changes? Will they be able to make changes through policies and activities that minimize adverse impacts (or make the most of the opportunities presented)? Or will the expected changes increase their vulnerability?
- Can adaptation take place at sector level, or is there a need for more structural changes within society (e.g., economic diversification)?

PART II

HOW TO MAP VULNERABILITY AND IDENTIFY ADAPTATION OPTIONS

Chapter 4 | Key Steps for Mapping Vulnerability and Identifying Adaptation Options

Chapter 4

Key Steps for Mapping Vulnerability and Identifying Adaptation Options

1

Determining and projecting hazards and perturbations and sensitivity refers to the nature of expected climate change and how it will be experienced by different sectors in a sub-national territory. This process provides actual empirical data based on observations and experiences. These steps are important as past hazards and sensitivity provide a proxy starting point for determining future hazards and sensitivity based on known probabilities of likely change. This step also assesses future exposure to climate risk and future sensitivity of sectors to that risk.

2

Assessing and projecting adaptive capacity refers to the human characteristics of society that mediate how hazards and sensitivity are taken up, and that ultimately determine whether society absorbs those changes without adverse effect, or whether they lead to negative impacts. In order to accurately assess and project the adaptive capacity of an area, the identification of proxies for adaptive capacity (e.g., investment capacity, education level) and other stresses that can interact with climate change impacts (e.g., unemployment, natural resource depletion, and aging population) is required. This step provides guidance on where to find data and interpret data for these exercises.

3

Integrating and mapping vulnerability refers to the review of information and results collected in Steps 1 and 2 and identifying a presentation method that shows these results spatially, so that locations can be identified where vulnerability is high and interventions may be required. Step 3 outlines the use of two tools: Geographic Information Systems (GIS) and expert opinion, which are often used in conjunction with each other to produce vulnerability maps.

4

Identifying adaptation interventions and considering the effect they will have on vulnerability is the last step presented in this guidebook. This step introduces the idea of setting up a system to evaluate the changes in vulnerability as climate changes under different socio-economic scenarios of development. It also outlines decision-making tools that permit prioritization of interventions (e.g., between sectors).

Summary of Key Steps

STEP 1

DETERMINE AND PROJECT HAZARDS AND SENSITIVITY

STEP 2

DETERMINE AND PROJECT ADAPTIVE CAPACITY

STEP 3

INTEGRATE AND MAP VULNERABILITY

STEP 4

IDENTIFY, ASSESS, AND REVIEW ADAPTATION OPTIONS

Step 1: Determine and Project Hazards and Sensitivity

Introduction

Determining and projecting climate change induced hazards and perturbations and sensitivity refers to the nature of expected climate change and how a range of possibilities will impact different sectors. The range of impacts is discernible at different scales (e.g., national, sub-national, or community level), depending on the relevance and types of management decisions that need to be made and information required to determine impacts. There are four main steps involved in this process. The first is to assess the past and present climate trends. The second is to assess the past and present sensitivity to known hazards (including both extreme events and incremental change). These first two steps are based on empirical data (i.e., based on observations and experiences). These steps are important as past hazards and sensitivity provide a proxy starting point for determining future hazards and sensitivity based on known probabilities of likely change. The third and fourth steps start to embrace uncertainty, as the exact types of future physical changes in climate and socio-economic changes that will affect sensitivity of sectors are unknown and could follow a number of different pathways. The third is assessing future exposure to climate risk, and the fourth is assessing future sensitivity of sectors to that risk. This section addresses each of these steps in turn, highlighting sources of data, what the information is likely to show, and how to build on each step in order to comprehensively assess the hazards and perturbations and sensitivity of the sub-national territory to long-term climate change. Case study experience is provided where appropriate at the end of each step.

“The exact types of future physical changes in climate and socio-economic changes that will affect sensitivity of sectors are unknown and could follow a number of different pathways.”

DEFINITIONS

Extremes

Climate and weather events that occur infrequently and mark peaks and troughs of the range of expected distribution, for example particularly high or low temperatures (heat waves or cold snaps), or floods, droughts and cyclones.

Time series

A sequence of data points or observations, typically measured at regular intervals (days, months, years).

Parameters

Elements of the climate that may vary.

1

- Assess Past and Present Climate Trends and Risks
- Assess Past and Present Sensitivity by Sector
- Assess Future Exposure to Climate Hazards and Perturbations
- Assess Future Sensitivity to Climate Change

Assess Past and Present Climate Trends and Risks

The first step in determining and projecting hazards and sensitivity to climate change involves looking at the existing and recent historical climate within the sub-national territory. This is important baseline information.

Sources of Data

National meteorological records exist within every country – albeit with varying degrees of history and accuracy. Meteorological data is typically collected by weather stations, with the data forwarded to the national weather service for storage. Contacting the national weather service should therefore elicit data on the major climate parameters: temperature and rainfall. Moreover, the national service should be able to provide time-series data (temperature or rainfall plotted over time – 3-month averages for each season) for each weather station, of which several may exist within the sub-national territory. Very rarely will daily measurements be useful or necessary for the task of mapping vulnerability in the context of supporting policy identification and formulation or to determine a particular response mechanism for implementation. There are technical and measurement issues which make the use of data at that scale and at that frequency impractical and unnecessary.

When reviewing data and graphs on climate trends (Box 4.1), several questions should be asked. A checklist is provided below (Table 4.1) for reference.

Box 4.2 outlines where to look if limited data is available from meteorological services on past and present climate parameters.

DEFINITIONS

Association

An association is a relationship between two measured variables when they are statistically dependent.

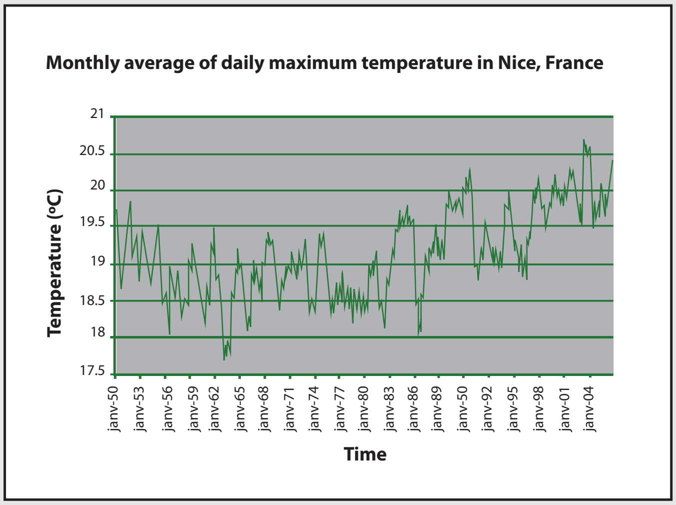
Correlation

Correlation indicates the strength and direction of a relationship between two measured variables; it can be positive (when one increases, the other increases) or negative (when one increases, the other decreases).

Causality

Neither association nor correlation implies causality. Two variables being statistically related or correlated may be a chance occurrence, or related to a third variable. This defines causality.

Box 4.1: Reading a Temperature Graph For Patterns and Anomalies



Source: Hallegatte, 2009 (pers. comm.)

This graph shows the monthly average of daily maximum temperatures in the city of Nice, in the south of France, for the years 1950-2004.

From 1950 to around 1980 temperatures were generally in the range 18-19.5˚C. From 1980 to 1991 there was a great degree of variation, with some temperatures rising above 19.5˚C (1980-83 and then 1986-89). The general trend since 1980 has been an increase in monthly average of daily maximum temperatures, and since 1998 this has always been in excess of 19.5˚C. The warmest monthly average was 20.5˚C in January 2001.

Table 4.1: Checklist for Reviewing Data and Graphs on Climate Change

Category	Question	Comment
Extremes	What are the extremes on the graph, and in what years did they occur?	For example, when was the highest temperature? When was the lowest temperature? When was the highest rainfall? When was the lowest rainfall? Is the period of time between extreme events getting shorter or longer?
Time Series	What is the overall trend over the time series?	Average climate is determined over a 30-year period, so several 30-year periods need to be included in order for change to be observed.
	Is there a general increase, general decrease, or does the trend stay the same over time?	This is known as inter-annual variability, or variability between years.
Parameters	How do the parameters vary within each year?	What is the extent of difference between the highest and lowest temperatures, and highest and lowest rainfall figures, within a year period?
	Does this change over the period of the time series?	Again, is there intra-annual variability, or variability within year?

Source: Based on Snover et al., 2007

Box 4.2: Where to Look if Limited Data is Available from Meteorological Services on Past and Present Climate Parameters

There are various sources where localized data can be obtained, very often free of charge:

- The United Nations Food and Agriculture Organization (FAO), AgroMet division, has compiled a database of climatic information gathered between 1961 and 1990 from close to 30,000 observation stations. This database, and applications designed to extract, analyze and map the data, are available online. http://freegeographytools.com/2007/fao-world-climate-data
- The International Research Institute for Climate and Society (IRI) has a climate data library that contains over 300 free datasets from a variety of earth science disciplines and climate-related topics that can be accessed, downloaded in a variety of formats (including GIS-compatible), and used to create visual representations of data, including animations. http://iridl.ldeo.columbia.edu/index.html
- The Intergovernmental Panel on Climate Change Data Distribution Centre collates global climate observations in both high and low resolution, and provides links to other data depositories. http://www.ipcc-data.org/obs/index.html
- Various satellites exist that can provide data on climate, or proxies for specific climate variables. (For example, satellites do not measure precipitation, but can measure soil wetness.) They also measure other factors relevant to vulnerability mapping, such as infrastructure (e.g., roads, buildings), agriculture (e.g., land cover, hydrological state of vegetation, crop irrigation, forest monitoring), geomorphology (e.g., coastlines, soil types, landscapes). Data can be extracted from:
  - Earth observation satellites intended for environmental monitoring (e.g., LANDSAT, SPOT, QuickBird, ENVISAT, TerraSAR-X, Radarsat)
  - Weather satellites, primarily used to monitor earth's weather and climate (e.g., TIROS, NOAA-AVHRR, METEOSAT, METOP)
  - Ocean observation satellites especially designed to monitor the oceans (temperature etc.) (e.g., MOS, SeaWiFS)

In the event that neither ground measurements nor satellite measures are available for specific spatial scale, there are statistical means of creating proxies providing there is some information with which to calibrate and verify. From the distributional patterns of certain parameters such as temperature, it is possible to make use statistical and econometric means to create proxy estimates of climate over different time and spatial scales. Calibration with known measures as well as simulation techniques can be used to understand the uncertainty surrounding such constructed estimates. For an example of the application of such techniques users may want to refer to papers such as Mendelssohn et al. (2007).

What Does this Data Show?

The answers to the above questions give crucial baseline data on the recent past and current climate of the sub-national territory, and the nature of change over time. This is important for identifying the occurrence of extreme events, such as droughts, floods (whether brought about by high rainfall or other hazards, such as tropical cyclones), and heat waves, all of which are generally projected to increase in frequency and magnitude under climate change. The answers also show whether or not there is a general difference in trends, which is also important, as climate change will also manifest in terms of long-term incremental change. Once this data has been obtained, it is possible to summarize the climate trends and risks (i.e., known probabilities). Caution must be exercised with regard to the limits of the data available.

When looking at data relating to climate change, variables with similar trends are often plotted together on graphs. When interpreting these graphs it is necessary to understand the meaning of three common statistical terms: association, correlation and causality. For example, ice cream sales and shark attack frequency are often positively correlated (i.e., both increase together). This does not mean that one causes the other – but the two variables exhibit a common response to warm weather. Similarly, when one sees variables such as crop yields and precipitation positively correlated, it is important to utilize this information and investigate further the causality behind the changes in crop yields. The extent to which precipitation changes contribute to changes (on the margin) in crop yields, while all other likely determinants are accounted for, must be determined using an appropriate analytical framework. There are a number of tools in the socio-science literature for this form of analysis.

Additional Resources

Satellite Data

Various web portals exist with repositories of satellite data that might be of use in vulnerability mapping in sub-national territories. These include:

- ENVISAT, ERS-1, ERS-2 - http://catalogues.eoportal.org/
- Terra/Acqua, MODIS-Terra, ASTER LANDSAT – http://glovis.usgs.gov/
- SPOT 1 – 2 -3 - 4 – 5 - http://catalog.spotimage.com/
- QuickBird 2 –http://www.digitalglobe.com/

DEFINITION

Sensitivity

The extent to which a unit of analysis reacts to stimuli. In climate terms, biomes, ecosystems, countries and sectors are all examples of units, which may have different levels of sensitivity when exposed to the same climate hazard or perturbation (depending on the scale of the analysis).

Assess Past and Present Sensitivity by Sector

Having determined the past and present nature of the climate within the sub-national region, the next step is to determine the sensitivity of various sectors – for example, population, agriculture, water, energy, tourism, fisheries, health, and biodiversity.

Sources of Data

Useful sources of data for assessing past sensitivity to climate hazards include sub-national authority archives, in particular the sub-national offices of sectoral departments and the media archives. For non-disaster sensitivity, other economic data sets can be used. For instance, energy or electricity consumption or tourism industry revenue is often measured and recorded by the national statistics authority. Electricity consumption or tourism industry revenue data can then be related to climate information (e.g., temperature), to assess how sensitive the economy was in the case of climate variations.

What Does this Data Show?

Unlike when assessing past and present hazards and perturbations, assessing past and present sensitivity requires an appreciation of the spatial distribution of hazards to hazards and climate parameters relative to different sectors. Flooding, for example, is likely to have occurred in specific locations within the sub-national territory, and this will have intersected with the locations of various sector facilities. With particular regard to the occurrence of extreme events, therefore, spatial risk mapping is often required to determine sensitivity. Overlaying hazards maps with sector maps highlights whether, for example, concentrations of the population are in the same location as hazards, such as floods. Archival data from sub-national authorities and the media will highlight the existence of past sensitivity by sector, and by location.

Additional Resources

Emergency Disaster Database

Depending on the size of the sub-national territory in question, data on the occurrence of past disasters is available in the International Emergency Disasters Database EM-DAT (EM-DAT - www.emdat.be).

DEFINITIONS

Hazard

A physically defined source of potential harm, or a situation with a potential for causing harm, in terms of human injury; damage to health, property, the environment, and other things of value; or some combination of these (CARICOM, 2003).

Preturbations

Small variations from the norm in the physical system, typically of lesser magnitude than a hazard, but possibly of longer duration. Perturbations may retrospectively be identified as incremental change.

Model

Models are representations of reality, and use actual observed data relating to various climate (and often ocean) parameters to represent a system.

Scenarios

Scenarios are plausible representations of future climate conditions.

Assess Future Exposure to Climate Hazards and Perturbations

Determinations of past and present hazards and sensitivity are fairly certain because they are based on observed empirical evidence. Levels of uncertainty increase when attempting to project these variables into the future, which can produce a range of results.

Sources of Data

The bulk of data relating to projected exposure to climate hazards and perturbations comes from computer-generated models. Box 4.3 provides an overview of a few well-known climate models. As the manifestation of climate change in the future depends on the quantity of emissions of greenhouse gases and their interaction with atmospheric processes, it is necessary to use scenarios – or the representation of a future state of a system. Scenarios are storylines of future demographic, social, economic, technological and environmental conditions, and are used to represent how society may unfold in the future. Four major scenarios are typically used when creating climate models. These were produced by the international scientific body that addresses climate change, the IPCC, in a Special Report on Emissions Scenarios (SRES) in 2000 (Box 4.4).

Different impacts require information at different spatial resolutions. Investigating droughts or heat waves can be done using a low-resolution model at 200 km, because these events have a spatial scale of hundreds of kilometers. Investigating heavy rainfall or hurricane risks requires very high-resolution models, as these events have very small-scale characteristics (e.g., storm rainfall can be particularly high over an area that is only a few kilometers wide). For further information refer to Puma, Gold et al., (forthcoming) *Guidance Document on Climate-Model Downscaling for Planning and Decision-Making*. As Box 4.3 shows, global climate models (GCMs) rarely give adequate resolution for sub-national level decision-making, but a number of web-based tools exist to provide data with sufficient resolution. Among these are UK Met Office PRECIS, MAGICC, SCENGEN, SERVIR – these tools provide the data as maps, which are easier to use than direct model outputs. Some of these tools include some downscaling to access the higher resolution needed to analyze floods or heavy precipitation (e.g., PRECIS), but have a more limited access to the uncertainty (fewer climate models); others do not provide downscaling, but give access to more model results (e.g., MAGICC). The choice of the tool depends on the hazard that has to be analyzed and on the aim of the study (impact analysis vs. adaptation analysis).

Global climate models are available from the IPCC or are easily accessible through meteorological office websites, or the websites of the institutions that produce the outputs of the major models (see Box 4.4). Most of the printed literature relating to future climate change is based on these model outputs.

"Models are representations of reality, and use actual observed data relating to various climate (and often ocean) parameters to represent a system."

Box 4.3: Global Climate Models

Models are representations of reality, and use actual observed data relating to various climate (and often ocean) parameters to represent a system. Using observed data as reference points, the models are tested to ascertain how well they predict what is currently observed, and then are forced under various future scenarios of emissions and underlying socio-economic changes to project how the climate system might react. Due to the high cost and labor intensity of designing, testing and running models (usually requiring super-computing facilities), relatively few models exist on a global scale. Those that do exist tend to be clustered around hubs of climatological and meteorological expertise and are typically located in universities or national meteorological services. Examples of world renowned centers that run climate models include the National Center for Atmospheric Research (NCAR) in the USA, the Hadley Centre for Climate Prediction and Research in the UK, the Max Planck Institute for Meteorology in Germany, the Commonwealth Scientific and Industrial Research Organization (CSIRO) in Australia, and Météo-France.

Global Climate Models (GCMs) produce data at low resolution – typically in grids of 200km by 200km, so while they can provide useful data on a global scale, their limited resolution means that they only give an indication of the large scale nature of change that can be expected, for example in terms of temperature and precipitation change. As a result, they can only give a broad-brush picture of projected changes in climate parameters at the sub-national level.

Figure 4.1, for example, shows the projected degree of temperature change across the world in two periods: 2020-2029, and then 2090-2099. This is useful for sub-national territories to at least determine the approximate extent of temperature change within their area. Caution is needed when using shorter-term climate projections (e.g., 2020-2030) because, over this timescale, the climate change signal remains limited and can thus be hidden by natural variability (the change in climate due to natural factors only). As model projections include natural variability, the actual climate condition can eventually be significantly different from model projections. This uncertainty makes it necessary to use – when available – multiple model results instead of only one. Over longer timescales (e.g., 2050-2060 or later), the climate change signal becomes much larger than natural variability, and the latter cannot hide or mask the former anymore. Since future climate change is still highly uncertain, especially at the local area, a single model can be misleading by giving the impression that only one future is possible. For instance, half of the available models project that precipitation over West Africa will increase, while the other half of the models project that it will decrease. No decision should be based on only one model, and using as many models as possible is an important requirement for vulnerability assessment and design of adaptation responses.

Sub-national planning processes can be supported with higher resolution data for such aspects as planning in water resources management, the maintenance of flood defenses, and building zones. Regional Climate Models (RCMs) attempt to increase the resolution for a smaller area of interest, for example 5000km x 5000km (the size of Europe, or southern Africa). Whereas GCMs determine the large scale effects of changing greenhouse gas emissions on global climate, RCMs use the effects on climate that result from the GCM (for example, the data shown in Figure 4.1), and are able to generate output data at resolutions as fine as 50km, 25km or even 10km. Bear in mind, however, that the level of uncertainty associated with regional models increases as the resolution becomes finer given the additional assumptions that must be applied to generate results.

Literature reviews are another useful method for accessing information for use in determining exposure to future hazards and perturbations, and sensitivity. In response to growing international awareness and recognition of the potential threats (and benefits) of climate change, academics and interest groups are undertaking more studies on the potential impacts climate change. Experts in the field will likely be able to point to the most useful sources of information. Of particular importance to sub-national level planners is the existence of studies and reports relevant to particular sectors that may have been undertaken either by government departments or interest groups. Since climate change is likely to particularly influence the availability of water resources for domestic and industrial use, not to mention that changes in water availability may also be accompanied by the increased risk of flooding, it is possible that the national, regional and even municipal government structures may have commissioned research into the explicit

Box 4.4: Special Report on Emissions Scenarios (SRES)

A1 - The A1 storyline and scenario family describes a future world of very rapid economic growth, global population that peaks in mid-century and declines thereafter, and the rapid introduction of new and more efficient technologies. Major underlying themes include convergence among regions, capacity building, and increased cultural and social interactions, with a substantial reduction in regional differences in per capita income. The A1 scenario family breaks down into three groups that describe alternative directions of technological change in the energy system. The three A1 groups are distinguished by their different technological emphasis: fossil intensive (A1FI), non-fossil energy sources (A1T), or a balance across all sources (A1B).

A2 – The A2 storyline and scenario family describes a very heterogeneous world. The underlying theme is self-reliance and preservation of local identities. Fertility patterns across regions converge very slowly, which results in continuously increasing global population. Economic development is primarily regionally oriented and per capita economic growth and technological change are more fragmented and slower than in other storylines.

B1 – The B1 storyline and scenario family describes a convergent world with the same global population that peaks in mid-century and declines thereafter, as in the A1 storyline, but with rapid changes in economic structures toward a service and information economy, with reductions in material intensity, and the introduction of clean and resource-efficient technologies. The emphasis is on global solutions to economic, social, and environmental sustainability, including improved equity, but without additional climate initiatives.

B2 - The B2 storyline and scenario family describes a world that emphasizes local solutions to economic, social, and environmental sustainability. It is a world with a continuously increasing global population at a rate lower than A2, intermediate levels of economic development, and less rapid and more diverse technological change than in the B1 and A1 storylines. While the scenario is also oriented toward environmental protection and social equity, it focuses on local and regional levels.

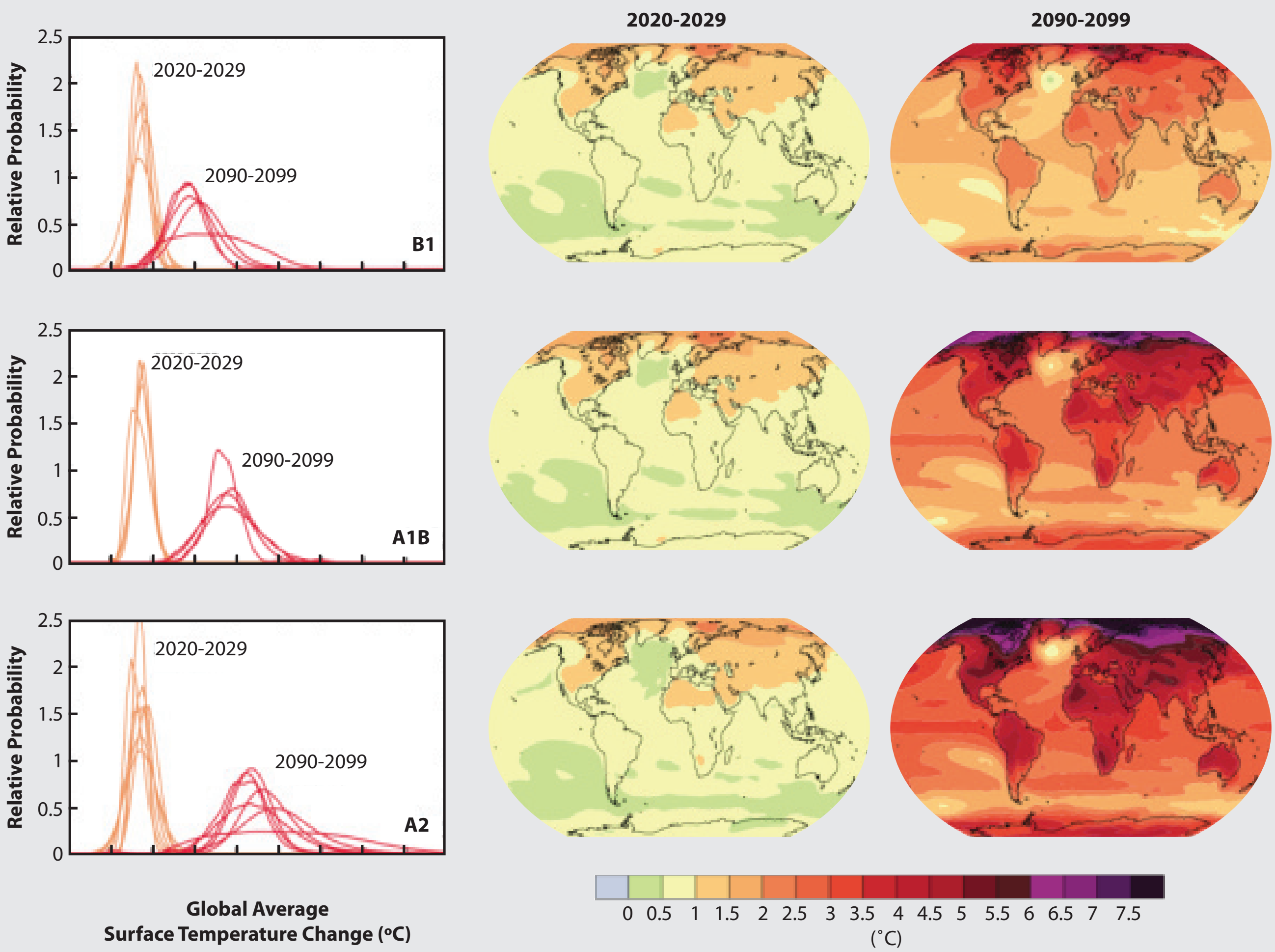
Source: IPCC, 2000

role of climate on water. Similarly, it is possible that a local wildlife or conservation organization will have researched the impact of climate change on biodiversity, if that is a particular consideration in the sub-region. Any existing information relevant to vulnerability within the sub-national territory should be looked into, in order to avoid duplicating efforts. This would also assist with the identification of appropriate stakeholders for inclusion in the process (as discussed in Chapter 2).

All Parties to the UNFCCC are required to submit a National Communication to the Conference of the Parties (COP). The report provides the COP with an overview of what steps countries are taking to implement the Convention. National Communications typically include an inventory of greenhouse gas emissions (and removals) and a vulnerability assessment. They may also contain information on national circumstances, financial resources and technology transfer, and education, training and public awareness. The reports are put together by the National Communications team, which is housed inside a designated government ministry. They contain inputs from relevant government parastatals (such as the meteorology service), academics, and technical consultants. They are useful repositories of country-specific information that can be of use in sub-regional vulnerability mapping.

Under the UNFCCC, Least Developed Countries (LDCs) prepare and submit a National Adaptation Programme of Action (NAPA). NAPAs identify areas that are most vulnerable to climate change and require urgent and immediate response in order for countries to adapt to climate change. They are also intended to report on the existence of coping strategies within LDC Parties, particularly at the grassroots level, to identify ways to enhance national adaptive capacity. They can thus also be useful sources of information for sub-regional vulnerability mapping, as they can highlight place-based case study information that

Figure 4.1: Projected Global Temperature Changes in the Periods 2020-29 and 2090-99 under Three Different Scenarios



Source: IPCC, 2007

shows where adaptive capacity is particularly high or particularly low. However, the quality of both National Communications and NAPAs is variable, and since they are produced infrequently, neither report should be used as the sole source of evidence.

Having found all the information that is available for the sub-national territory in question – and some regions will have better availability than others – the next step is to ask a series of key questions about the projections of key climate parameters (such as temperature and precipitation) and hazards and how they relate to the past and present climate. The overarching question is "how is temperature/rainfall projected to change during the 21st century?" As in section 2.4, changes need to be observed relating to trends, extremes, and inter- and intra-annual variability. A list of questions is provided in Box 4.5 to help in determining such information.

Box 4.5: Checklist for Evaluating Credibility of Written Sources

I'm not an expert: how can I evaluate the credibility of a source?	
Question	**Comment**
Are the authors clearly identified as experts?	Academic literature and major synthesis reports are generally subject to a system of "expert refereeing", whereas conference proceedings, reports, and in particular web-based sources are not (unless they are direct representations of a peer-reviewed source).
Do the study results make sense?	Is the source held together by solid logic, with conclusions based on reasonable assumptions and the data presented?
Are the results placed in the context of existing understanding?	Scientific knowledge is built on the testing and interpretation of previous studies. Are the assumptions, analytical techniques, and conclusions well referenced with citations to relevant and credible information?
Is there supporting evidence for the author's conclusions?	If multiple authors come to the same conclusion independently, the conclusion is more likely to have credibility (e.g.,the IPCC reports on the state of science have the agreement of many of the world's leading scientists).
Does the study address uncertainty?	Since projecting climate change involves uncertainty, all reports should address this, and ideally offer ranges of possibility rather than a single representation.
What are the potential biases?	Who benefits from the study's conclusion? Who funded the study? Are the interests and values of the authors apparent? What are your personal biases in reviewing this work?
How old is the study?	The science of climate change is rapidly evolving, so the timeliness of materials is important. With any studies using climate models, it is important to determine the generation of models and scenarios that the study relies upon.

Source: Snover et al., 2007

What Does this Data Show?

The outputs of the various data sources highlighted above are information on the projected nature of climate hazards and perturbations, in terms of both extreme events and incremental change, in the sub-national territory. Given that the exact nature of climate change in the future is not known, and depends on a variety of factors – not least how much the anthropogenic emissions of greenhouse gases increase – there are likely to be several potential examples of hazards, based on different scenarios. As is also clear from this section, a variety of data sources are available. In some cases the range of data can be overwhelming for planners to assess. Different sources rarely correspond as they tend to be based on different assumptions, thus a range of outcomes is likely to exist. Table 4.2 gives an example of categories of information that should be sought from the various data sources in order to yield data that is credible. Given that climate change science is an ever-evolving field, and more and more new information becomes available every day, it is also advisable that someone be given responsibility for monitoring and updating this data as appropriate.

Box 4.6: Questions to Determine Trends, Extremes, and Inter- and Intra-Annual Variability

Question	Comment
What are the projected extremes in the future?	• What is the highest temperature? • What is the lowest temperature? • What is the highest rainfall? • What is the lowest rainfall? • Are these extremes bigger or smaller than present and past extremes of temperature and rainfall?
What is the projected periodicity of extreme events (e.g., droughts, floods, heat waves) in the future?	• How does it differ from present and past periodicity? • In other words, is the period of time between extreme events getting shorter or longer?
Inter-annual variability: what is the overall trend in the future?	• Is there a general increase, general decrease, or does the trend stay the same over time? • How does the trend relate to present and past data? • Are the changes bigger or smaller than variations between cold and warm or wet and dry years in the past? Is the rate of change increasing?
Intra-annual variability: how are the parameters projected to vary within each year?	• What is the difference between the highest and lowest temperatures, and highest and lowest rainfall figures, within a year period? • How does this compare to present and past data?
Can I find episodes of the past that look like what I expect in the future?	• These kinds of "natural experiments" are useful to assess what are possible impacts and societal responses.

Source: Snover et al., 2007

Table 4.2: Example of how to Compile Information from a Variety of Sources on Hazards to Climate Change

Summary of projected climate changes for your sub-national territory						
Climate variable	**General change expected**	**Specific change expected and reference period**	**Size of projected change compared to recent changes**	**Information about seasonal patterns of change**	**Confidence**	**Source(s) and context**
Precipitation (Mediterranean region of Europe)	Large decrease	-4 to -27%	Projected change is significant compared to the range of precipitation observed during the 20th century	Larger decrease in summer when water is already the scarcest	-changes in precipitation are less certain than changes in temperature	IPCC, 2007
Precipitation (Pacific Northwest of the USA)	Very small increase	-4 to +7% (2020s) -4 to +9% (2040s) Compared to 1970-1999 average	Projected change is very small relative to the range of precipitation observed during the 20th century	Slight decreases in summer and slight increases in winter	-changes in precipitation are less certain than changes in temperature -changes in summer precipitation are less certain than changes in winter precipitation -future years projected to continue to swing between relatively wet and dry conditions, making it likely that the change due to climate change will be hard to see	Publication: Snover et al., 2007 Projections derived from ten climate models from IPCC 2007 simulating changes associated with high and low greenhouse gas emission scenarios. Geographical region is the PNW, defined as Washington, Oregon, Idaho and western Montana

Source: Based on Snover et al., 2007

Additional Resources

Web-Based Model Tools

- PRECIS – http://precis.metoffice.com/new_user.html
- MAGICC (Model for the Assessment of Greenhouse Gas-Induced Climate Change) – http://www.cru.uea.ac.uk/cru/projects/magicc/
- SCENGEN (A regional climate SCENario GENerator) – http://scengen.net/
- SERVIR – www.servir.net
- IPCC – www.ipcc-data.org (most of this data is in NetCDF format)
- NetCDF – http://www.unidata.ucar.edu/software/netcdf/

National Communications to the UNFCCC

National Communications can be downloaded directly from the UNFCCC website:
http://unfccc.int/national_reports/items/1408.php

National Adaptation Programmes of Actions

National Adaptation Programmes of Action can be downloaded directly from the UNFCCC website:
http://unfccc.int/cooperation_support/least_developed_countries_portal/submitted_napas/items/4585.php

Assess Future Sensitivity to Climate Change

Looking at present and past sensitivity to climate change shows that different sectors are not affected by similar hazards in the same way. This will also be the case when assessing the future. As with assessing future hazards and perturbations, assessing future sensitivity is also subject to uncertainty, as it involves making predictions about the development and evolution of society, which of course may proceed in different ways. This sub-step assesses the sensitivity of sectors in conjunction with project climate data.

Sources of Data

In addition to the climate projections listed in Table 4.2, socio-economic data on projected pathways of development is critical for determining future sensitivity to climate change. At the national level and in the short- to medium-term, countries typically outline their development priorities through strategic plans or development plans. Various ministries also often produce sectoral plans, which highlight commitments to various goals. These are particularly important once vulnerability has been identified and mapped, and subjective decisions must be taken on prioritizing various risks – as it is important for sub-regional strategies to be consistent with national political commitments. Similarly, any socio-economic data collected at the national or sub-national level – for example in the form of census information or questionnaires – might provide useful data for projecting future vulnerabilities using appropriate methodologies in the literature. As with the case of assessing future hazards to climate risks, it is difficult to take into account how sectors will evolve in the future, although some sectors are easier to predict than others. For instance, it has been established over time through empirical studies that energy and water consumption generally increase with wealth. This empirical relationship (which is testable) is useful to take into account when

DEFINITION

Expert Judgment

The opinion of experts used to elaborate scenarios and relate climatic variables with sector sensitivity and adaptive capacity.

determining the rate at which energy and water management assets will increase in the future. In some sectors, such as urban development, prediction is a much more difficult exercise.

The methods used to assess future sensitivity can either be based on expert judgment, past proxies of relationships between climate parameters and economic variables (such as energy consumption), or deterministic, reduced form models. These methods are listed in order of increasing technical skill and capacity. As with all steps in this guidebook, the simplest one can be applied in any sub-national territory, and although it may have a bigger margin of statistical error than the more complex methods, it will still yield useful information that can be successfully used in identifying vulnerability and decision-making to manage the known and unknown risks of climate change on a given system/sector.

"As with assessing future hazards and perturbations, assessing future sensitivity is also subject to uncertainty, as it involves making predictions about the development and evolution of society, which of course may proceed in different ways."

Box 4.7: Back-of-the Envelope Estimate of Likely Costs of Climate Change Induced Heat Waves

It is possible using information that is readily available to estimate the likely future costs of climate change induced events such as heat waves. For exposition purposes, the following example is based on the heat wave event in France referenced above. In such cases where climate events are tracked, using supplementary information from climate change models, it is possible to project, within known ranges of error, the likely rate of similar types of events (e.g., heat waves) occurring over time in defined geographical settings. Most meteorological institutes (national, regional, international) engage in this type of monitoring. Based on projected information, the expected number of heat waves that are similar in intensity to known events (such as the 2003 heat wave event) can be determined under a range of climate change scenarios. This would permit the extrapolation of the likely economic and social implications, under a set of assumptions about socio-economic conditions in the future. In the following example, two criteria were used to define the likely range of incidences of a 2003-like event: 12 days with a temperature more than 5°C above the current average and 11 days with a temperature more than 8°C above the current average (see Table 4.3).

Using the number of projected incidences, multiplying the estimated cost of the 2003 event by the number of likely events in the 2010-2030, 2010-2050, and 2010-2100 periods provides a plausible assessment of the energy-related cost of climate change-induced heat waves. While this is a simple, linear and rough approximation, it is nonetheless useful information to sub-national planners to inform resource allocation and other decisions to manage the uncertainties of climate change.

A similar approach can be used to provide a first-order approximation of the likely costs of a river flood in locations where floods are frequent: if climate change is expected to increase their frequency, the cost can be estimated by multiplying the average cost of a flood (based on estimates today) by the increase in the number of additional floods that are expected. If the intensity of floods is expected to increase, then a multiplying factor can be applied to the average cost of a flood, to get an order of magnitude of the future losses. Even though such a method is very simple, it may be the only plausible option to fall back on when a detailed hydrological model cannot be developed.

Table 4.3: The Number of Heat Waves of 2003 Magnitude Occurring in the Future Depending on Two Different Scenarios (Using Météo-France GCM)

Scenario	2010-2030	2010-2050	2010-2100
A2	[0 - 3]	[2 - 11]	[32 - 51]
B2	[0 - 1]	[1 - 4]	[18 - 25]

What Does this Data Show?

The most qualitative method for determining future sensitivity of sectors to exposed climate change involves expert judgment. While models, scenarios, and hard data have a role in determining future exposure in an objective and structured way, expert opinion can also play a key role in this process, including assessing sensitivity. Two examples of experts are important in this regard: academics and technical staff in public and private institutions focusing on climate sensitive sectors such as agriculture, water, and energy. Academics who have studied climate change impacts are likely to be able to elaborate on climate change scenarios and impact scenarios and provide reasoned judgments on the sector's sensitivity to exposure. Similarly, technical staff from the different sectors will be experienced in how sectors have been affected by present and past climate. They will also have insights into the potential future development of their sector.

Past proxies of relationships between climate parameters and economic variables can be used both with regard to cross-sectional data, time series of data, or data surrounding an infrequent extreme event. If time series (longitudinal) data series of both the climate parameter and economic variable exist – say for example temperature and energy consumption, then using a range of statistical and econometric analyses can provide a result in the form of statements like "if temperature is higher by 1°C, then electricity consumption is likely to change by x%." The determinants of this change could also be identified, including the marginal contribution that each has on the estimated rate of change (for example, the adoption of air conditioning, wealth, location, demographic factors, etc). Then this relationship can be used to assess how electricity consumption would change if the average temperature increases as projected by climate models. In the same way, annual agricultural yields and climate conditions (e.g., maximum/average temperature, total rainfall during the growing season) are modeled in agronomy and exhibit correlation. This correlation, if correctly analyzed, can be used to get a first-order estimate of how vulnerable agriculture yields or income from agriculture are to climate change, subject to the choices made by farmers.

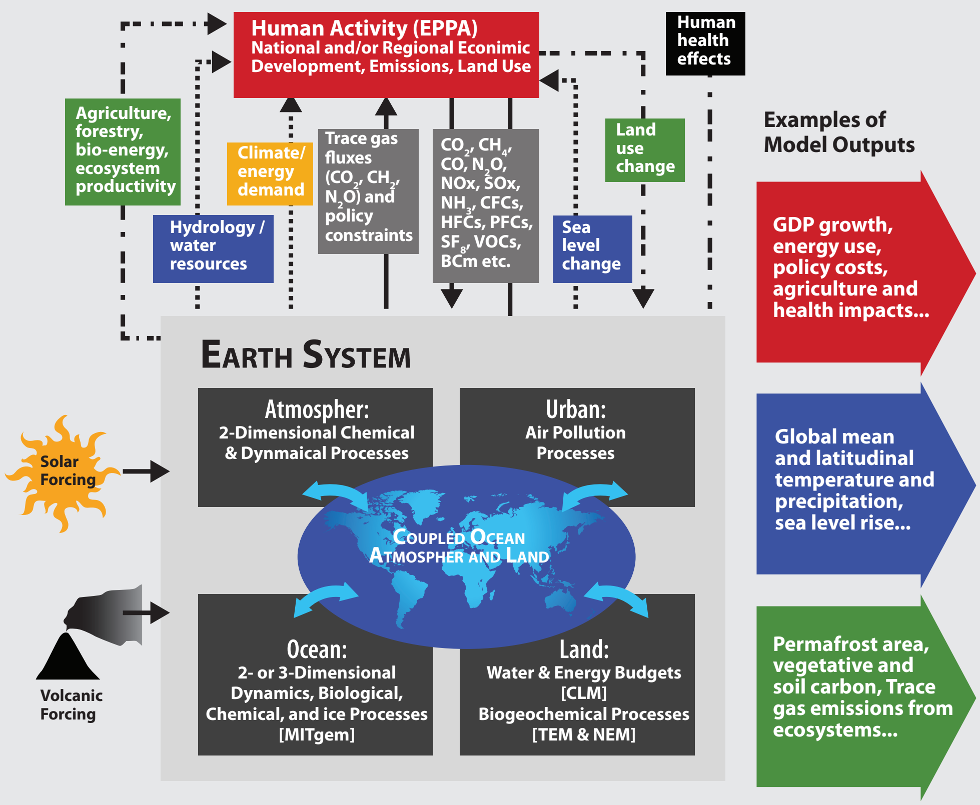
Similarly, single event data can be used when past events are good proxies for what is expected in the future. In France, for instance, the summer temperature during the 2003 heat wave was close to what is expected in an average summer in 2080 in the A2 scenario. This event could therefore be used to investigate the likely expected consequences of climate change. For instance, electricity had to be imported at a high price in France during the 2003 summer because of insufficient domestic production. The cost was estimated at €300million.

Note that while the above approaches may provide a pragmatic way forward, where information is scarce, the methods based on historical data have several limitations. First, they consider short-term perturbations around the current climate. The consequences of long-term, permanent perturbations due to climate change may be very different: potentially lower due to autonomous adaptation that is likely in the case of a long-term change; or higher, because repeated events can be more destructive than single events (for instance, a forest may be able to cope with one heat wave in a decade, not with two or more). Another limitation is due to the fact that the future climate may be totally different from the current one: in a region where temperature has been between 15 and 25°C, historical data cannot tell anything about the consequences of a temperature of 30°C.

Because of limitations of using historical data, it is also possible to use mathematical models to simulate both observed as well as likely future conditions. Dynamic multi-sector, sector, and household level models are used frequently for examining climate change impacts and adaptation at the international, national, regional, and household level. In the case of agriculture, there are four competing strands of research into the economic impacts of climate change on agriculture: agronomic, panel data, agro-economic and Ricardian (also known as hedonic valuation) approaches. The agronomic approach relies on carefully controlled experiments to identify optimal conditions for crop growth. Armed with this information, it is possible to then introduce various interventions (changes in temperature, changes in rainfall, etc) and simulate impacts. Panel data studies examine the impact of weather over time. Agro-economic models take farmers' yield losses as given, and predict the implications on yields as climate changes and farmers reduce the impact by switching crops. The Ricardian modeling approach captures the actual adaptations that farmers make and measures the final net impact. This range of analytical approaches is equally common in other contexts such as for measuring the impact of climate change on river flooding, coastal inundation, and water supplies, among others. In most cases, information from a variety of other modeling tools and approaches such as for land use, hydrology, soils, population and other socio-economic variables will be required. This factor implies that modeling approaches entail significant amount of time and work

"Where information is scarce, the methods based on historical data have several limitations."

Figure 4.2: The Current Framework and Processes of the Massachusetts Institute of Technology's Integrated Global System Model Version 2 (IGSM2)



Source: MIT, 2009. Note: Joint Program on the Science and Policy of Global Change (http://globalchange.mit.edu/)

(often requiring specialized technical skills), which is not always easily available. Also, it is essential to note that results from these models cannot be blindly trusted: these results have domains of validity, which must be explicitly recognized. For instance, these models can predict a large increase in agricultural yields because of better temperature. This increase may be more than compensated for by the appearance of new pests due to higher temperatures that are not included in the agricultural yield model. Results from these models have to be analyzed and interpreted by experts who are familiar with the models and know their limitations. Such experts are likely to exist within academia or within specialized climate and meteorology services.

In a few sectors, simplified models (calibrated on past and/or current data) exist and can be used for this type of analysis. An example is the use of degree-day and cooling-degree-day models. These models are based on the idea that heating is used only when temperature is below a given value (often 18°C). Moreover, energy consumption for heating purposes is assumed to be proportional to the number of degree-days. Typically, only a few observations are necessary to calibrate this very simple function that can be used to assess how higher temperatures could translate into lower energy demand.

For natural risks, in particular, the geographical aspect is essential and needs to be taken into account. This can be done using risk mapping. Two methods can again be used: based on past events or a full model approach. Using past events, if a large flood has affected a region, the corresponding flood footprint may be available. This footprint represents a region that is known to be risk-prone. Where flood risks are expected to increase because of climate change (for instance, because rainfall is expected to increase), this increase in risk can be taken into account through an enlargement of the existing footprint. This enlargement can be done using a complex hydrological model if available, or from expert opinion if no model is available.

A full model approach is also possible with flood footprints that are provided by a climate model and coupled with a hydrological model. This approach is an option, but is demanding in terms of time, money, technical proficiencies, and data. In particular, it requires a good Digital Elevation Model (DEM) database. Such databases, often accessible for no cost through the Internet are regarded as far more accurate than freely available information from satellite observations. If DEM data is available, then hydrological models such as the Storm Water Management Model (SWMM), a US-EPA model for urban watersheds (available on http://www.epa.gov/ednnrmrl/models/swmm/), and appropriate climate change models can be combined to understand likely implications in the future under a range of scenarios. Using these models, however, requires the use of downscaled datasets that are not always available for all places. There are ways in which to secure detailed data for certain variables that are critical for the analysis, but such work requires a significant investment from expert teams.

There are also means of understanding the likely implications of climate change using complex integrated approaches. Figure 4.2 depicts the current framework and processes of the Massachusetts Institute of Technology's Integrated Global System Model Version 2 (IGSM2). Solid lines between model components indicate exchanges represented in standard runs of the system; dash-dotted lines indicate model connections that exist and have been utilized in targeted studies that examine the implications of climate change on a range of factors such as GDP growth, agriculture impacts, energy use and others. However, even such approaches have a range of limitations including as yet incomplete understanding of feedback loops in what is a very complex system.

Conclusion

"This information should help answer the question of whether impacts will remain in some vulnerable sectors or whether they are so large that they will have cross-sectoral and macroeconomic components."

Using the various approaches and consulting the various sources of data outlined in this step will yield four sets of information:

- Past and present exposure to climate hazards and perturbations
- Past and present sensitivity of sectors to climate change
- Future climate change exposure to hazards and perturbations
- Future sensitivity to climate change

The data available for the first bullet points above will largely be based on actual and observed information. For the last two bullets, however, analytical work will require information based on expert judgment and/or models that generate the information under user defined assumptions. It will be clear from this step that one of the biggest problems with determining vulnerability to future climate is the inherent uncertainty (see Box 4.8 for a summary). Various methods can be utilized to address these four questions, with the general rule-of-thumb that the greater the resolution of data, the greater the input required in terms of finances and technical capacity. However, the bottom-line is that assessing the nature of hazards and perturbations, and sensitivity, are two vital components of vulnerability in a sub-national territory, and thus even the most basic methods yield data that is more useful than nothing at all.

This information should also be able to support inferences about the scale of the climate change impacts in the country. In particular, it should help answer the question of whether impacts will remain in some vulnerable sectors or whether they are so large that they will have cross-sectoral and macroeconomic components. Depending on their scale, impacts have to be analyzed differently (for example, using cross-sectoral investigation) and adaptation options are different (for example, structural economic diversification becomes essential).

Box 4.8: Summary of Sources of Uncertainty in Identifying Sub-National Level Vulnerability to Climate Change

Physical Manifestation of Climate Change. The climate system is so complex, and subject to so many interactions and feedbacks, that modeling has to be based on assumptions. The assumptions must therefore be transparent and fully understood.

Response to Changing Socio-Economic Circumstances. Another layer of uncertainty comes when we try to simulate how the climate system will respond to different levels of greenhouse gas emissions. The nature of greenhouse gas emissions in the future will depend on a number of political, social and economic factors which themselves are constantly changing: such as the growth of industrial activities within the developing world, and the extent of political agreement to cut emissions reached through the UNFCCC. As it is not possible to look into the future, the current practice is to use the four scenarios outlined in Box 4.4. The four scenarios capture the full range of likely future outcomes that should be factored in any analysis. The frequent tendency to focus on any specific scenario from which to draw policy conclusions should be avoided.

Data (Un)Availability. As shown above, the accuracy of climate data that is generated from GCMs is affected by the paucity of atmospheric and oceanic data available to input into the model. The instrumental record of past climate data, for example from weather stations, only goes back 200 years at most, and is spatially variable, with not all areas having well maintained and regularly read weather stations. Planners will soon realize that the data they would like, and the certainty they would like, in order to make decisions is often not available with regard to climate change. Adopting "no regrets" solutions is therefore a good framework with which to integrate the issue of climate change into plans.

Local Socio-Economic Circumstances. Depending on future local evolution, future vulnerability can be very different. For instance, city vulnerability will depend on population fluxes in the city: if a city population increases so rapidly that infrastructure (e.g., electricity, drainage, sanitation) cannot follow pace, the vulnerability will increase significantly. On the other hand, if required infrastructure can be provided thanks to local economic growth and development, vulnerability will decrease. So, local versions of the world socio-economic scenarios need to be designed. In absence of such local scenarios, a first step can be the assessment of the current economic vulnerability. Working on the current economy has limitations, but it makes the process much simpler and represents a starting point.

Case studies

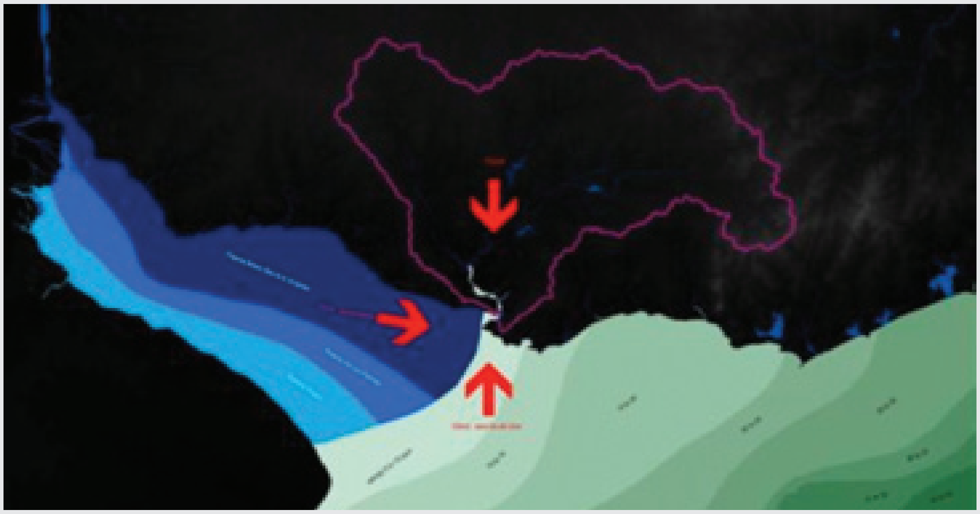
Assessing and Mapping Exposure to Water-Based Hazards in Uruguay

According to scientific evidence, climate changes in Uruguay are likely to result in a gradual increase in temperatures (+1.5°C in both winter and summer) and an increase in precipitation (+5% by 2050) – leading to a more tropical climate, and sea level rise. Estimates suggest that it is very probable that the region will experience more intense and more frequent extremes events such as droughts, floods and storms.

Local and external experts agree that the highest risk to Uruguay is the change in water availability. The maps below show the main components of the hydrology within a sub-national regions in Uruguay (the Montevideo area) and the main conduits through which exposure to climate change is likely to take place. These include the alluvial contribution coming from the Rio de la Plata (as it drains an important part of South American soils through the Rio Parana and the Rio Uruguay), the sea's influence through saltwater intrusion, the various sources of pollution and places of catchments, and the behaviour of the Rio Santa Lucia.

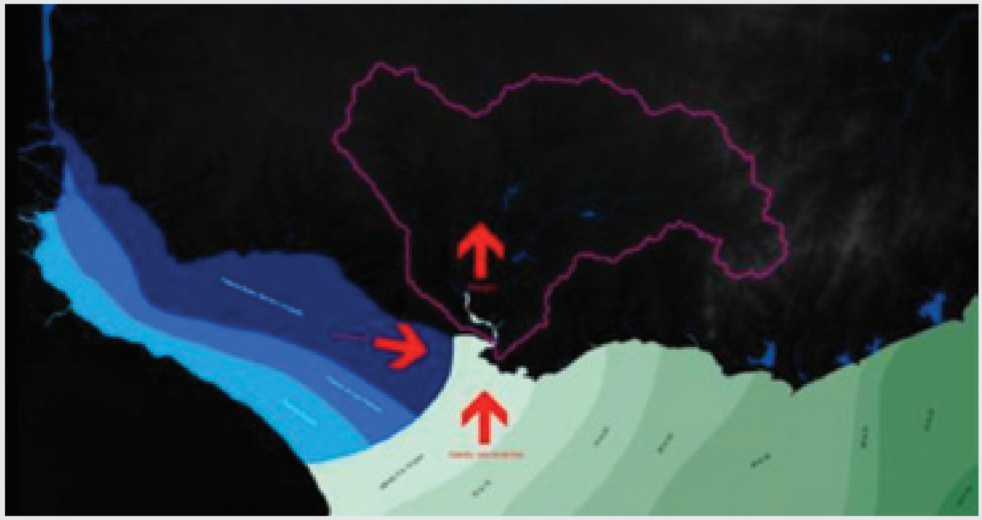
The Rio de la Plata estuary is composed of three hydrological corridors depending mostly on the three different confluent dynamics. The Rio Uruguay plays a significant part in the dynamics of the Rio de la Plata during periods of flood – the water level can increase by 10 cm within a few weeks of an intensive rain period. Extreme and intense rain events can also provoke floods. Such phenomena, and agronomic parameters, are accentuated significantly by southeast winds and partially by ocean swells. Flood risks within an area are also determined by climate and non-climate related sediment-clogging phenomena because of the significant alluvial components carried by the rivers, particularly the Rio de la Plata.

Figure 4.3: Winter Forcing Factors of the Hazards of Water Resources in the Metropolitan Area of Montevideo, Uruguay



Source: ClimSAT Brest

Figure 4.4: Summer Forcing Factors of the Hazards of Water Resources in the Metropolitan Area of Montevideo, Uruguay



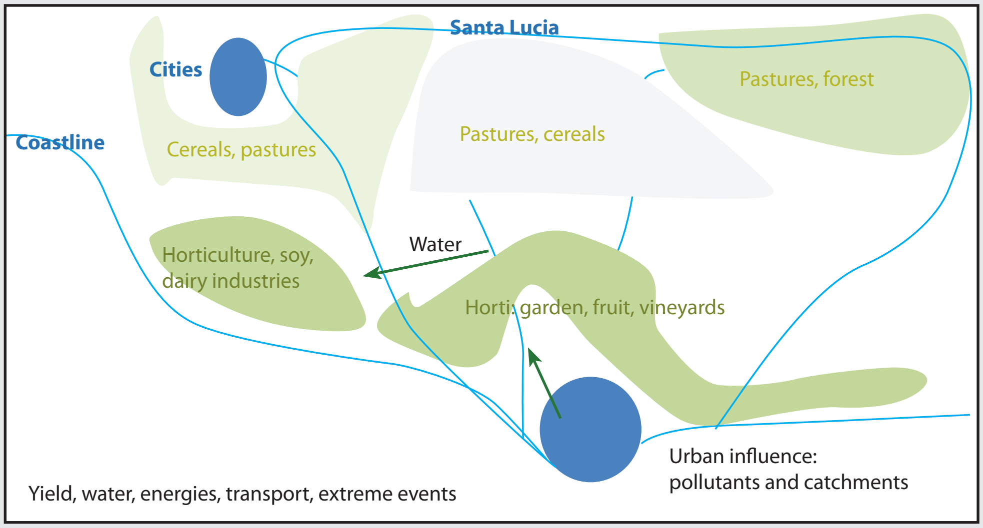
Source: ClimSAT Brest

"Local and external experts agree that the highest risk to Uruguay is the change in water availability."

Historically, during the rainy winters and subsequent spring seasons in this region of South America, river discharges reach their maximum. It is not uncommon that the volume of surface water exceeds the carrying capacities of the rivers and of the water basins. This is especially the case for the Santa Lucia water basin, where the main exit point is the Delta del Tigre, nearly 10 kilometers west from the center of Montevideo. Furthermore, these overflows are also common for the Rio de la Plata, which carries a large sediment load. The discharges are significant and the strong currents carry water and sediments towards the Delta del Tigre direction. Adding to these initial forcing factors, the south and southeasterly winter winds drive the sea currents towards the coastal zone of the metropolitan area of Montevideo. The combination of these two forcing factors impedes the discharge of the Santa Lucia in the Rio de la Plata, and can increase the risk of flooding in late winter (Figure 4.3).

During the summer and fall, river discharges are lower. Water flows from the Rio de la Plata and concentrated alluvial elements are swept away by the currents towards the coastline of the metropolitan area of Montevideo. The probability of clogging in the Delta del Tigre is therefore accentuated by the small river outflow of the Santa Lucia River, which reduces the capacity of the flow to carry away the sediments. During this same period the south and southeasterly winds drive the sea currents towards the metropolitan area of Montevideo. Saltwater can enter the river at the Delta del Tigre. Eventually, during summer, the metropolitan area of Montevideo is exposed to saltwater intrusion and the clogging of sediments phenomenon, adding to the drought tendencies in the Santa Lucia water basin (Figure 4.4).

Figure 4.5: Hazards of Agriculture and Food Production to Climate Changes in the Metropolitan Area of Montevideo, Uruguay



Source: ClimSAT Brest

Assessing and Mapping Sensitivity of Agriculture to Water-Based Hazards in Uruguay

Changes in water availability will also play a role in agriculture and food production. In the metropolitan area of Montevideo in Uruguay, 70% of the population's food needs are covered by the hinterland. Therefore, this territory is strongly dependent on its agriculture. This is positive because it makes the territory largely independent of reliance on food imports and limits transportation costs and related greenhouse gas emissions, but at the same time it emphasizes the degree of vulnerability of the population to climate change in the territory. Furthermore, the demographic growth and the energetic trends increase the area's degree of hazards. Figure 4.5 shows the main exposed agricultural and food production assets within Montevideo.

Assessing and Mapping Sensitivity to Water Availability Changes in Uruguay

To determine future sensitivity, start by using information on past events as an input to the process of determining the likelihood of future events. Table 4.4 shows the incidences of flood events in Uruguay.

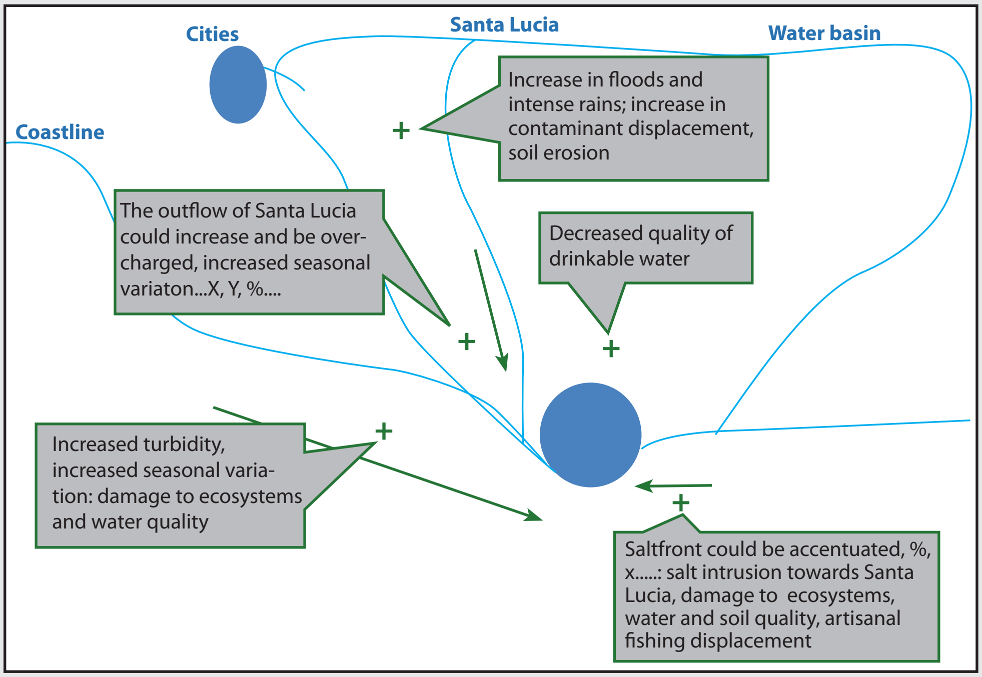
The probability of occurrence of such events can be predicted by the intensity of rainfall on X days:

Y mm of precipitation on X days

The return period between such events is also an important variable explaining flooding events. The number of months where this limit is exceeded corresponds to vulnerable months and thus vulnerable years. The probable number of events based on this intensity threshold every 5 years can then be expressed. This information, together with assumptions about how likely it is that climate and socio-economic factors will change, and other key factors that matter in explaining the likelihood of an extreme event, can be used (in conjunction with appropriate statistical methodologies) to project future likelihood of events.

> To determine future sensitivity, start by using information on past events as an input to the process of determining the likelihood of future events.

Figure 4.6: Sensitivity of Water Resources to Climate Changes in the Metropolitan Area of Montevideo, Uruguay



Source: ClimSAT Brest

Note: Figure 4.6 summarizes the current sensitivity of water resources to climate change in the metropolitan area of Montevideo, Uruguay – highlighting concerns for drinking water quality, saltwater intrusion, and flooding (in winter) and droughts (in summer).

Table 4.4: Flooding Events in Uruguay since 1967

Disaster	Date	Total Affected People
Flood	05/04/2007	119,200
Flood	1967	38,063
Flood	August-1986	18,500
Flood	04/11/1998	9,300
Flood	05/16/2000	5,000
Flood	June 2001	5,000

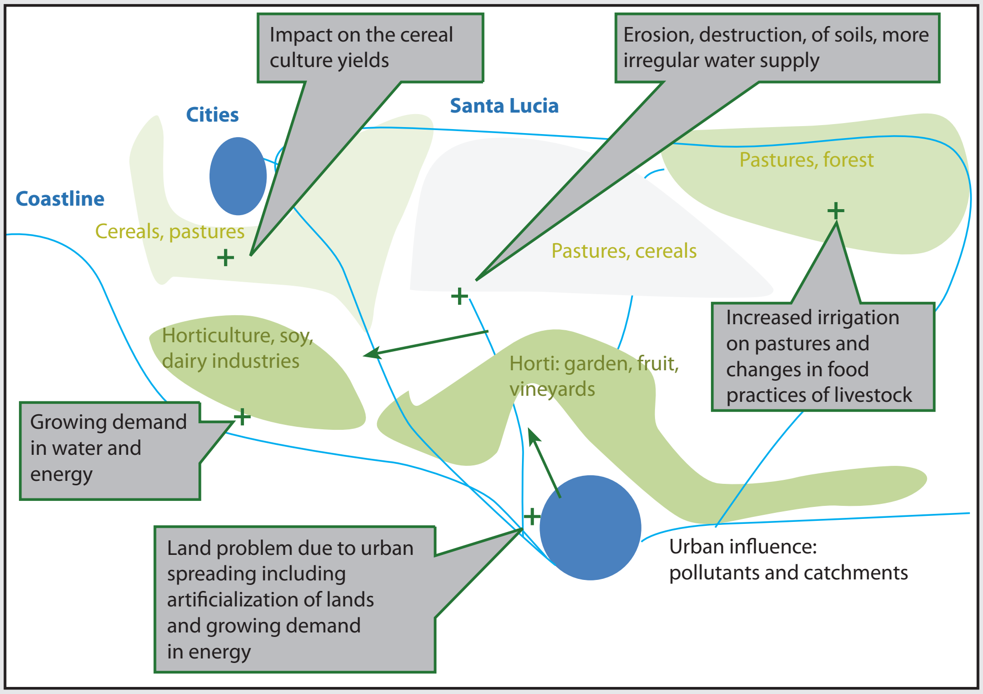
Source: EM-DAT: The OFDA/CRED International Disaster Database – UCL

Note: Table 4.4 shows the evolution of frequency and intensity of extreme events since 1967 in the vicinity of Montevideo. Future climatic data can then be analyzed and interpreted through this unit of perception of vulnerable years.

Assessing and Mapping Agricultural Sensitivity to Water Availability Changes in Uruguay

In Uruguay, projected long-term climate change trends suggest wetter winter periods and drier summer months. Expectations are that cereal and fodder production could be severely impacted. In addition, more frequent and intense extreme events such as floods, droughts or storms could induce additional damage to agricultural production in both the short and long term.

Figure 4.7: Sensitivity of Agriculture and Food Production to Climate Changes in the Metropolitan Area of Montevideo, Uruguay



Source: ClimSAT Brest

Step 2: Determine and Project Adaptive Capacity

Introduction

Step 1 outlined how to determine present, past and future hazards and sensitivity to climate change. As outlined in Chapter 3, however, these are only two elements of vulnerability to climate change. The third element is adaptive capacity, referring to the human characteristics of society that mediate how society is able to anticipate, cope with and respond to hazards and perturbations to which it is exposed. Adaptive capacity ultimately determines whether society absorbs those changes without adverse effect, or whether they lead to negative impacts. Moreover, climate change is not the only stress on economies and societies. A region that has to deal with other negative stresses will be less able to cope with climate change and adapt to its consequences. It might be the case, for example, that a particular sector is highly exposed and highly sensitive to future climate risks, but also has a high adaptive capacity. Given that vulnerability is a function of all three components, this sector would possibly be deemed less vulnerable than one that is highly exposed, but has a low adaptive capacity. In particular, adaptive capacity varies at the micro level; and now that climate change is a recognized risk and adaptive responses are being implemented, the impact of these adaptations on vulnerability needs to be assessed. It is therefore important to identify proxies for adaptive capacity (e.g., investment capacity, education level) and to identify other stresses that can interact with climate change impacts (e.g., unemployment, natural resource depletion, and aging population).

DEFINITIONS

Adaptation

Adjustment in natural or human systems in response to actual or expected climate changes or their impacts, so as to reduce harm or exploit beneficial opportunities.

Adaptive Capacity

The potential or capability of a system to anticipate, cope with and respond to an external stress, such as climate variability and change.

“Adaptive capacity refers to the human characteristics of society that mediate how society is able to anticipate, cope with and respond to hazards and perturbations to which it is exposed. Adaptive capacity ultimately determines whether society absorbs those changes without adverse effect, or whether they lead to negative impacts.”

2

- Identify Proxies or Indicators for Adaptive Capacity
- Identify Other Stresses that Can Interact with Climate Change as Driving Forces of System Change

Identify Proxies or Indicators for Adaptive Capacity

Sources of Data

As with the previous step on assessing hazards perturbations and sensitivity, several sources of data are available for assessing adaptive capacity, and they range from low input, in terms of finances and technical capacity, to high input. Either way, assessment of adaptive capacity tends to use largely qualitative methods. Arguably the most comprehensive way of assessing adaptive capacity is through the use of context-specific indicators that are increasingly being developed by academics and practitioners working in the climate change field. Consulting academics and undertaking literature reviews will determine whether these are available for sub-national territories. However, more often than not indicators will not be available, in which case expert judgment is preferred. A case study is provided at the end of this sub-section that highlights the adaptive capacity process in Uruguay.

Indicators are quantifiable constructs that simplify a complex reality, and are of particular use in charting change through time. For each sector of interest, an indicator needs to be chosen that is appropriately sensitive, but also realistic in terms of data needs, to monitor change in performance over time. Often a strategy must be put in place to gather, or if data is already collected via another mechanism, to manage, this data. For example at the national level, the greater the degree of reliance of an economy on natural resource-dependent socio-economic sectors, such as agriculture, fishing and forestry, arguably the lower the level of adaptive capacity in the face of climate change. Various appropriate

> "Indicators are quantifiable constructs that simplify a complex reality, and are of particular use in charting change through time."

indicators exist at the national level which accurately reflect this phenomenon: among them contribution to GDP, or number of people employed in natural resource-dependent sectors. They are particularly useful for adaptive capacity as they enable qualitative spatial data to be displayed in a format which is compatible with biophysical data generated through models and can be overlain in GIS (see Step 3).

At the national level various instruments are used to collect data from which appropriate indicators can be compiled. Examples include census, household survey, or panel data. At the sub-national level, however, data for use in indicators often needs to be directly collected for the purpose of vulnerability assessments. This is a time-consuming and resource-intensive job.

What Does this Data Show?

The results of indicators of adaptive capacity, or expert judgment on adaptive capacity by sector, show which sectors have high adaptive capacity and which sectors have low adaptive capacity in the face of climate change.

Identify Other Stresses that Can Interact with Climate Change as Driving Forces of System Change

Expert judgments with regard to assessing adaptive capacity can be obtained through consultations with experts working in sectors that have been identified as relevant to the process (e.g., population, agriculture, water, energy, tourism, fisheries, health, and biodiversity). These experts could include representatives of special interest organizations, such as conservation societies or private sector partners, for example, in the case of water, energy and tourism, or planning officials with responsibility for a particular sector (e.g., forestry). In the case of external stakeholders, as well as being thoroughly versed in the issues within their sector, they may be able to provide access to specialist reports or publications highlighting research on the potential impacts of climate change on their sector. In the case of internal stakeholders, their specialized sectoral knowledge can be drawn upon to elicit adaptive capacity.

Expert judgment should be able to shed light on both present and future adaptive capacity by sector. One way to elicit and gather information is to organize a participatory roundtable and invite representatives from relevant sectors as identified above. Table 4.5 outlines a list of questions relating to adaptive capacity, to which experts can assign the values low, medium or high for current adaptive capacity (or use existing indicators where appropriate – for example, when measuring health status, indicators may already be collected showing average distance to healthcare facility, etc). Future adaptive capacity is much more difficult to predict, because as with future hazards and sensitivity, it is subject to a range of outcomes which have yet to be determined. Arguably future adaptive capacity is even more complex to predict than hazards and sensitivity, since it depends on the introduction of adaptive measures, and their implications. National Communications to the UNFCCC include information on climate change projections as well as priority mitigation and adaptation policies and measures by sector (energy, transport, mining, waste, agriculture, forestry, health, water resources and biodiversity).

These questions/indicators can be used to show/project adaptive capacity at the sub-national level (e.g., by district), or to show spatial variation within a district.

Table 4.5: Checklist of Questions to Ask Experts when Considering the Adaptive Capacity of a Sub-National Territory

Question	Comment
What is the country's Human Development Index?	
What is the local level dependency ratio?	
What is the percentage of female-headed households?	
What is the percentage of households caring for orphans?	
What is the percentage of households claiming a disability grant/other cash transfer indicating vulnerability?	
What is the level of the resources within the sub-national territory?	
What is the savings and investment capacity of the population?	
What is the structure of institutions and decision-making authorities? Is there a strong and well-capacitated local government structure?	
What is the level of human capital in the sub-national territory?	
What is the level of education?	
What is the health status?	
What is the level of public perception of risks, including climate change?	
What proportion of the population is dependent on primary industries (farming, fishing and forestry) for the bulk of their livelihoods?	
What is the level of early warning and disaster preparedness?	

Source: Snover et al., 2007

What Does this Data Show?

The results of indicators of adaptive capacity, or expert judgment on adaptive capacity by sector, show which sectors have high adaptive capacity and which sectors have low adaptive capacity in the face of climate change.

"Determining adaptive capacity is arguably the most difficult of the three components of vulnerability."

Box 4.9: Local Level Participatory Vulnerability Assessment in Ghana

In Ghana, CARE is working with local communities to promote the integration of climate change adaptation issues into the Medium Term Plans (2010-2015) for two districts in northern Ghana – East Mamprusi and Bawku. Using the CARE Vulnerability and Capacity Assessment (CVCA) process, key vulnerability issues were identified in target communities, with a particular emphasis on vulnerable groups. The process demonstrated the impacts of climate change in the region, with floods, droughts and erratic rainfall identified as key issues facing target communities. The analysis also yielded information on the particular vulnerability of women, who are largely responsible for maintaining family well-being, are often left behind by male family members who migrate in search of work, and who have insecure access to important resources such as land. This analysis is being used as the basis for the development of Community Action Plans, which identify the priority actions to reduce vulnerability to climate change.

The project is combining bottom-up and top-down approaches by strengthening communities' capacity to communicate their needs and priorities to decision-makers while also working with District officials to promote participatory planning processes. The project is placing particular focus on ensuring that women play a leading role in local governance by promoting their engagement in Area Councils and community-based organizations, and by strengthening their capacity to advocate for women's rights. The expected outcomes of the project include District Plans that incorporate the climate change adaptation priorities of vulnerable people, and increased capacity to adopt a participatory approach to local governance. Promoting district-level action to reduce vulnerability, while addressing some of the systemic inequalities that increase vulnerability of women, will build adaptive capacity to address future climate impacts.

Source: CARE CVCA Handbook, 2009

Additional Resources

NGO Toolkits on Adaptive Capacity

A number of NGOs have produced toolkits and advice on conducting primary assessments of adaptive capacity at the local/community level. Some sources include CARE's CVCA Handbook and National Disaster Management Institute's (INGC) *Toolbox for mapping the vulnerability of communities* (Kienberger, 2008). These assessments require primary research and are thus too time- and money -intensive for use at the sub-national level. However, they are a good initial source for experts as they begin the expert judgment process. Box 4.9 (above) outlines an example of the use of CARE's CVCA Handbook in Ghana.

Conclusion

Determining adaptive capacity is arguably the most difficult of the three components of vulnerability, and thus tends to be dependent on qualitative methods such as expert judgment.

Case Study

Adaptive Capacity in Uruguay

Based on indicator data, adaptive capacity in Uruguay, and particularly in the metropolitan area of Montevideo, is high. Uruguay is one of eight countries in Latin America that has a Human Development Index (HDI) in excess of 0.8. The country ranks 40th out of 173 on the world HDI list. Uruguay has the third highest level of life expectancy in Latin America (after Argentina and Chile) and one of the highest levels of education of the world. With specific regard to climate change, it was one of the first Latin American countries to sign the Kyoto Protocol and is highly committed to the issue.

Several adaptation strategies for water resources are possible in Uruguay because of existing assets at the sub-national level to reduce vulnerability to an anticipated range of climate change impacts. These strategies include:

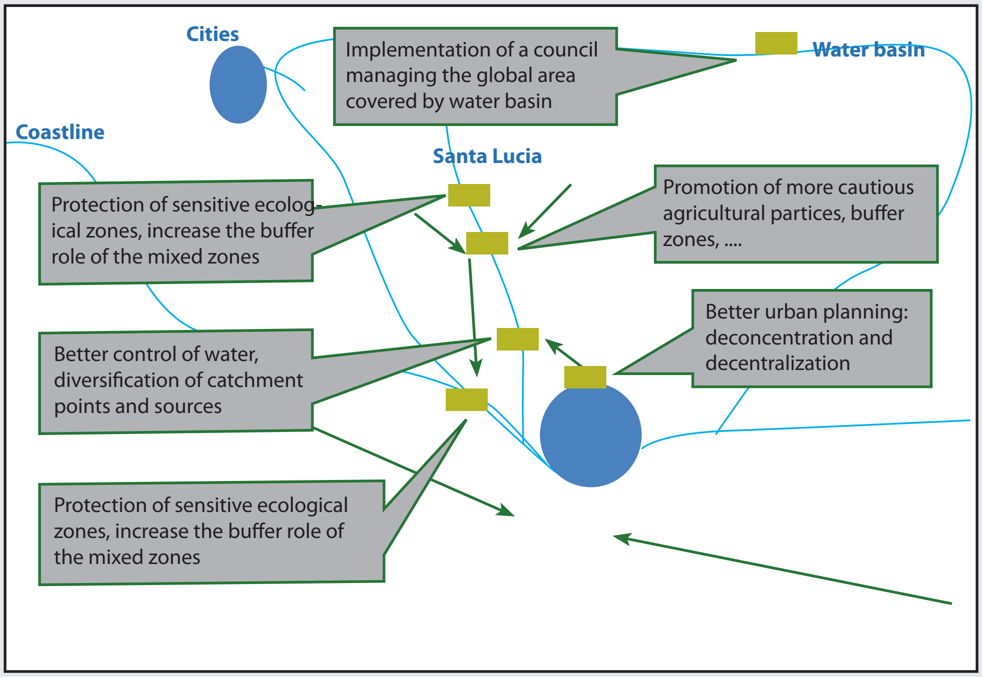
- Improving control of the water flows, for example, by diversifying the catchment
- Managing the Rio de la Plata evacuation and the Rio Santa Lucia estuary, for example, through protection and the creation of sanctuaries
- Integrating and proposing a more holistic management of the water basins (including industries, agriculture, ecosystems) with sustainable direct actions (e.g., filtration, buffer coastal zones and buffer banks, protected sensitive zones, more cautious agricultural practices in terms of potentially polluting inputs)

These strategies vary with regard to implementation costs, feasibility, and implementation time. The options are depicted schematically in Figure 4.8.

Similarly, adaptation strategies exist to reduce the vulnerability of the agricultural and food production systems to climate change. These include:

- Promoting conservation agriculture that is less dependent on inputs in the context of likely climate change-induced changes in the availability of specific inputs
- Limiting the expansion of residential land use onto potentially cultivable lands (taking into account where the cultivable lands are likely to be as the climate changes)
- Promoting climate-resilient management practices of the agricultural systems at the water basin scale.

Figure 4.8: Adaptive Possibilities of Water Resources and Uses in the Metropolitan Area of Montevideo, Uruguay



Source: ClimSAT Brest

Step 3: Integrate and Map Vulnerability

Introduction

Having identified hazards and perturbations, sensitivity and adaptive capacity (as outlined in Steps 1 and 2), the next step is to identify a presentation method that shows these results spatially, so that locations can be identified where vulnerability is high and interventions may be required. Mapping is particularly important for natural risk management, especially for land-use management. For instance, only mapping can help define a land-use planning strategy that reduces the society's vulnerability to coastal floods by concentrating new development in safe locations. In other sectors (e.g., health impacts), mapping may be less crucial and aggregated assessment may be sufficient.

Given that vulnerability = exposure to climate hazards and perturbations x sensitivity – adaptive capacity, all three elements needs to be included in the map. This is because, as previously explained, an area of high hazards to change will not translate into vulnerability if the social and biophysical environments are not sensitive to that hazard. This step outlines the use of two tools: GIS and expert judgment, which are often used in conjunction with each other to produce vulnerability maps.

> "This step outlines the use of two tools: GIS and expert judgment, which are often used in conjunction with each other to produce vulnerability maps."

DEFINITION

Geographical Information System

A computer system for capturing, storing, checking, integrating, manipulating, analyzing and displaying data related to positions on the Earth's surface. Typically GIS is used for handling maps of one kind or another. These might be represented as several different layers where each layer holds data about a particular kind of feature (e.g., roads). Each feature is linked to a position on the graphical image of a map. Layers of data are organized to be studied and to perform statistical analysis (e.g., combining flood risk maps, with area development plans).

STEP 1
DETERMINE AND PROJECT HAZARDS AND SENSITIVITY

STEP 2
DETERMINE AND PROJECT ADAPTIVE CAPACITY

STEP 3
INTEGRATE AND MAP VULNERABILITY

STEP 4
IDENTIFY, ASSESS, AND REVIEW ADAPTATION OPTIONS

3

- Use of Geographic Information Systems
- Use of Expert Judgment and Tracing Paper

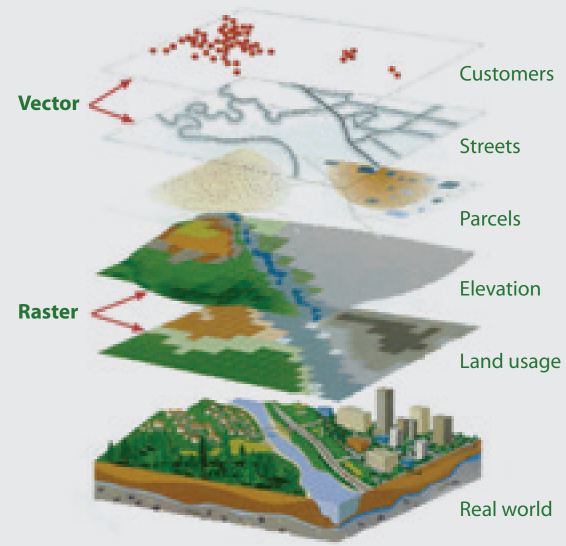
Geographic Information Systems

Geographic Information Systems (GIS) are powerful tools used to store, manage, analyze, manipulate, and present spatial data (i.e., data that is location-specific), including both natural resources and socio-economic phenomena (see Figure 4.9). GIS are therefore useful for displaying data that may have been obtained on hazards and perturbations, sensitivity, and adaptive capacity in a place-based format. This allows for the identification of locations with high vulnerability to climate change. Examples of where a GIS might be used in a planning context include the distribution of natural resources within a region, or perhaps unemployment figures. GIS is particularly useful as it enables different data layers to be presented together in the same map, and the scales of data collection do not need to be identical (for example it is possible to have one layer of sub-district level data, and one layer of district level data). For determining vulnerability to climate change, it is possible to overlay physical hazards data with socio-economic adaptive capacity data. As a result, hotspots of vulnerability can be identified – where there is an intersection of high exposure to hazards and perturbations and low socio-economic adaptive capacity.

While the advantages of GIS are apparent, there are also some disadvantages. Commercial GIS software is typically expensive and requires technical skill to use. That said, many sub-national territories will already be using GIS for other

> "GIS is particularly useful as it enables different data layers to be presented together in the same map, and the scales of data collection do not need to be identical."

Figure 4.9: How GIS Works to Overlay Different Layers of Data



Source: http://ssnds.uwo.ca/sscnetworkupdate/2006winter/gissupport.html

planning purposes, and may have a surveying or information management department where technical expertise rests and baseline data (e.g., on administrative boundaries and infrastructure such as roads and railway lines) exists. It is important to identify if your sub-national territory has a survey/GIS department with appropriate software, expertise and existing data sets that may be of use for climate vulnerability mapping. If it does, such expertise should be included in a technical steering committee. It would also be important to assess the availability of data within the region. The cross-cutting nature of climate change means that data collected by other departments is likely to be of importance: for example, the availability of surface water resources/hydrology, together with physical data such as ground height and shape. Combined with the distribution of population, this could highlight hotspot flood risks.

GIS is not essential for vulnerability mapping. While it is a nice tool, it requires robust and reliable data to be available, and needs someone with an understanding of the nature and driving forces of vulnerability to choose what to input and manipulate – otherwise it runs the risk of "garbage in, garbage out." This is particularly dangerous because it is easy to be uncritical of such technical outputs – and poorly designed GIS maps can mask real vulnerabilities while overstating others.

Additional Resources

GIS Software

Open source GIS software is freely available for download on the Internet. Examples include:

- Grass - http://grass.itc.it/
- Quantum GIS (QGIS) - http://www.qgis.org/
- gvSIG - http://www.gvsig.gva.es/eng/inicio-gvsig/

DEFINITIONS

Cost-Benefit Analysis (CBA)

A technique that quantifies the costs and benefits (monetary and/or social) of a project over time, and thus can be used to evaluate its utility or effectiveness.

Multi-Criteria Analysis

A technique for evaluating complex problems, which highlights dimensions of conflict (which is typically a prerequisite for effectively addressing them).

Risk Assessment

A technique to determine the quantitative and or qualitative value of risk related to any given situation.

Expert Judgment and Tracing Paper

In the absence of GIS, simple but effective vulnerability maps can be produced by hand, using vinyl or tracing paper over a political or physical map of the sub-national territory to mark areas of high vulnerability, hazards and low adaptive capacity that have been identified in Steps 1 and 2. In order to streamline information, only the most critical risks of hazards and sensitivity and the lowest identified adaptive capacity could be mapped. This would support the primary purpose of vulnerability mapping, which is to identify the high vulnerability areas where interventions may be required, but still may result in creation of several maps (based on various exposure/sensitivity scenarios and socio-economic adaptive capacity scenarios).

Based on the previous steps, it is possible that there will be several maps as outcomes (based on various exposure/sensitivity scenarios, and various socio-economic adaptive capacity scenarios). The next step is to decide on the desired future by evaluation with cost-benefit analysis, multi-criteria analysis, or risk assessment. These types of tools can provide additional information that a decision-maker can utilize to decide on which interventions to pursue. Normative judgment will be required so as to determine which specific set of interventions needs to be followed, including political considerations such as no regrets/low regrets solutions.

Producing vulnerability maps is an essential prerequisite to the next stage of the process – risk assessment. This is where subjective discussion and negotiation needs to take place to identify a system of prioritizing action to reduce vulnerability, in accordance with other political priorities.

As shown from the steps above, vulnerability is a dynamic condition that results from the interaction of hazards, sensitivity and adaptive capacity, all of which are likely to change in unknown ways in the future. It is therefore imperative to have a mechanism for charting how vulnerability might change over time, particularly to determine the effectiveness (or otherwise) of any adaptation strategies adopted with the intention of reducing vulnerability.

Indicators are quantifiable constructs that simplify a complex reality, and are of particular use in charting change through time. Indicators need to be chosen as appropriate to each sector of interest, and a strategy must be put in place to gather, or if data is already collected via another mechanism, to manage, this data. They are particularly useful for adaptive capacity as they enable qualitative data to be displayed in a format, which is compatible with biophysical data generated through models and can be overlain in GIS (see Figures 4.10-4.12).

"Vulnerability is a function of exposure to climate hazards and perturbations, sensitivity, and adaptive capacity."

Conclusion

Vulnerability is a function of exposure to climate hazards and perturbations, sensitivity, and adaptive capacity. This step provided examples of how to visually present levels of vulnerability in a certain area. This type of presentation makes it easy to identify places that are most vulnerable to climate change. The mapping process will likely result in a range of images that reflect both current and future concerns that are based on various scenarios that are used when considering exposure to hazards and perturbations and adaptive capacity. The maps produced are only snapshots and are static, based on specific inputs related to climate hazards and perturbations, sensitivity, and adaptive capacity. As soon as any of the three components change, the outcome will change, and as it has been pointed out in Steps 1 and 2, exposure to climate hazards and perturbations, sensitivity, and adaptive capacity are all subject to change. Vulnerability mapping must therefore take place at regular intervals. The monitoring process is crucial and serves as a tracking tool to verify the effectiveness of adaptation interventions on vulnerability reduction. Step 4 discusses adaptation options.

Case Studies

Mapping Territorial Vulnerability in Uruguay

As highlighted in previous examples, the main vulnerabilities of the metropolitan area of Montevideo have to do with human settlements. The area also has an extensive coastline, and coastal vulnerability has been considered critical in terms of sea level rise and extreme events. Other key vulnerabilities include the agricultural sector, which is largely dependent on precipitation and water resources, like the Santa Lucía River, that provides drinking water for Montevideo. The Ministry of Environment has done some studies on local vulnerabilities, but additional work is needed to have a better understanding of the key vulnerability issues at the local scale. A recent law has made it mandatory for departments to prepare territorial planning documents. This should provide a good opportunity to integrate climate change into planning strategies from the start.

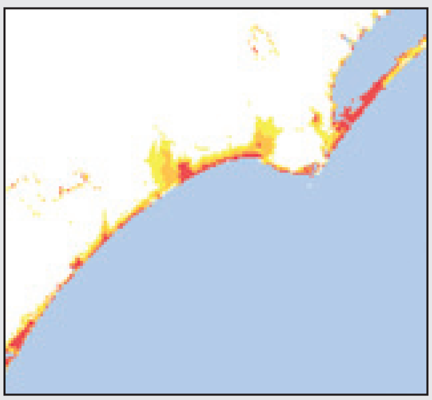
Mapping Vulnerability in Languedoc-Roussillon Using GIS

Using GIS to map vulnerability of urban areas and flood infrastructure in Languedoc-Roussillon, France

Figure 4.10: Urbanized Areas of Languedoc-Roussillon

Source: Hallegatte and Dumas, 2009

Figure 4.11: Exposure to the Hazard of Sea Level Rise in Languedoc-Roussillon

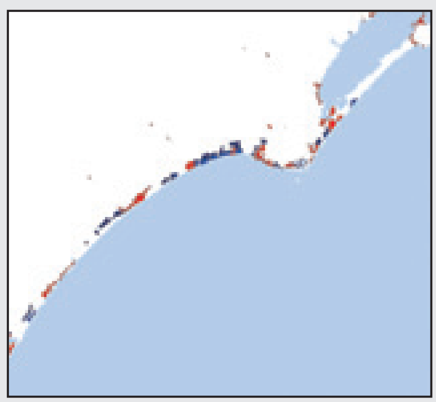


Hazards to sea level rise (SLR)
Red = areas between sea level and a 1m elevation
Orange = areas at elevation between 1 and 2m
Yellow = areas at location between 2 and 3m

Red areas are at risk of coastal flood from the 10- year return period storm surge (short-term rise in sea level due to storm), and at risk of being submerged by 1m SLR. Orange areas are at risk of coastal flood from the 100-year return period storm surge, and would become at risk of coastal flood from the 100-year return period storm surge with a 1m SLR (i.e., a multiplication by 10 of the flood probability). Yellow areas are considered safe today, but will be at risk of coastal flood from the 100-year return period storm surge with a 1m SLR. For all colored areas, flood risks will increase with SLR. Other locations are protected by their elevation.

Source: Hallegatte and Dumas, 2009

Figure 4.12: Areas Vulnerable to Flooding from Sea Rise in Languedoc-Roussillon



Hazards to SLR
Red = Residential Areas
Orange = Industrial Areas
Blue = Transportation Infrastructure

Figure 4.12 shows an overlay of Figure 4.10 and Figure 4.11, showing urbanized areas in which a 1m SLR would increase the flood risk.

Source: Hallegatte and Dumas, 2009

Step 4: Identify, Assess, and Review Adaptation Options

DEFINITION

Normative Judgment

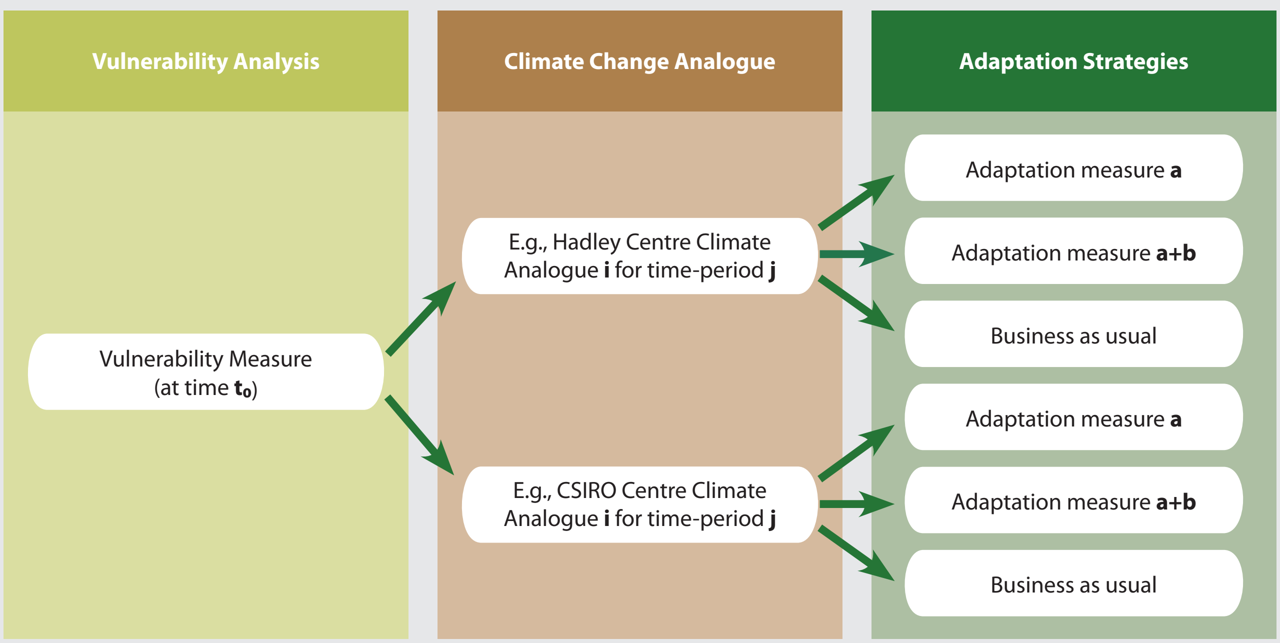
A statement that is based on belief and expresses judgment on whether a phenomenon is deemed right or wrong. Different stakeholders will likely have different normative judgments, and as elected representatives, politicians are typically left to decide the appropriate options.

Introduction

Identifying and mapping vulnerability within a sub-national territory is an important step in a more comprehensive process of moving towards low-emission and climate-resilient sub-national territories. Having identified vulnerability, the logical next step is to decide on adaptation interventions and consider the effect they will have on that vulnerability. As shown in the previous steps, scenarios for climate change are based on a range of possible trajectories, from conservative to more extreme estimates of change. As a result, sub-national planning must take into account the range of possible futures and ensure that decisions are robust in the face of these scenarios. That is, adaptation interventions need to respond to both known risks and the uncertainty of possible climate change futures.

Unlike identifying vulnerability, this step requires normative judgments on the prioritization of interventions. This step introduces the idea of setting up a system to evaluate the changes in vulnerability as climate changes under different socio-economic scenarios of development. It also outlines decision-making tools that permit prioritization of interventions (e.g., between sectors). Due to the intensely normative nature of this exercise, stakeholder consultation and participation is imperative. Given that adaptation choices require a long-term view of how the sub-national territory will look in the future under alternative (ranging from conservative to extreme) scenarios, consultation processes should even be extended to the general population at large.

Figure 4.13: Key Steps in Assessing Adaptation Options



Source: Kurukulasuriya et al. (2008) in Charting A New Low-Carbon Route to Development, UNDP, 2009

Identify Adaptation Options

The first step is compiling a list of all possible adaptation options, without consideration to their efficiency; adaptation is a new challenge and new and innovative strategies have to be promoted. There are two main mechanisms to do this: expert judgment and spatial analogues.

Expert Judgment

With expert judgment, identification of adaptation options takes place with the inputs of sector representatives. In addition, there will be a need to identify generic and holistic adaptation strategies that are not related to a single sector but are of relevance to multiple sectors (e.g., improvement of information and communication about climate change and improvement in meteorology observation systems). Both soft and hard engineering solutions may be part of the mixture of responses. Even though these solutions will be necessary, legal, financial, and institutional changes also have to be considered. For instance, early warning systems, evacuation plans, and financial support to micro-insurance schemes may be useful to cope with more frequent floods of limited intensity, instead of building dikes that are costly and dangerous in case of failure. Requiring water management agencies to prepare long-term plans to start thinking about climate change constraints, and to design contingency plans in case of droughts, can improve resilience to such events at low cost. Making clear who in the administration is responsible for risk management and providing resources to do so may also be a very efficient step toward better adaptation.

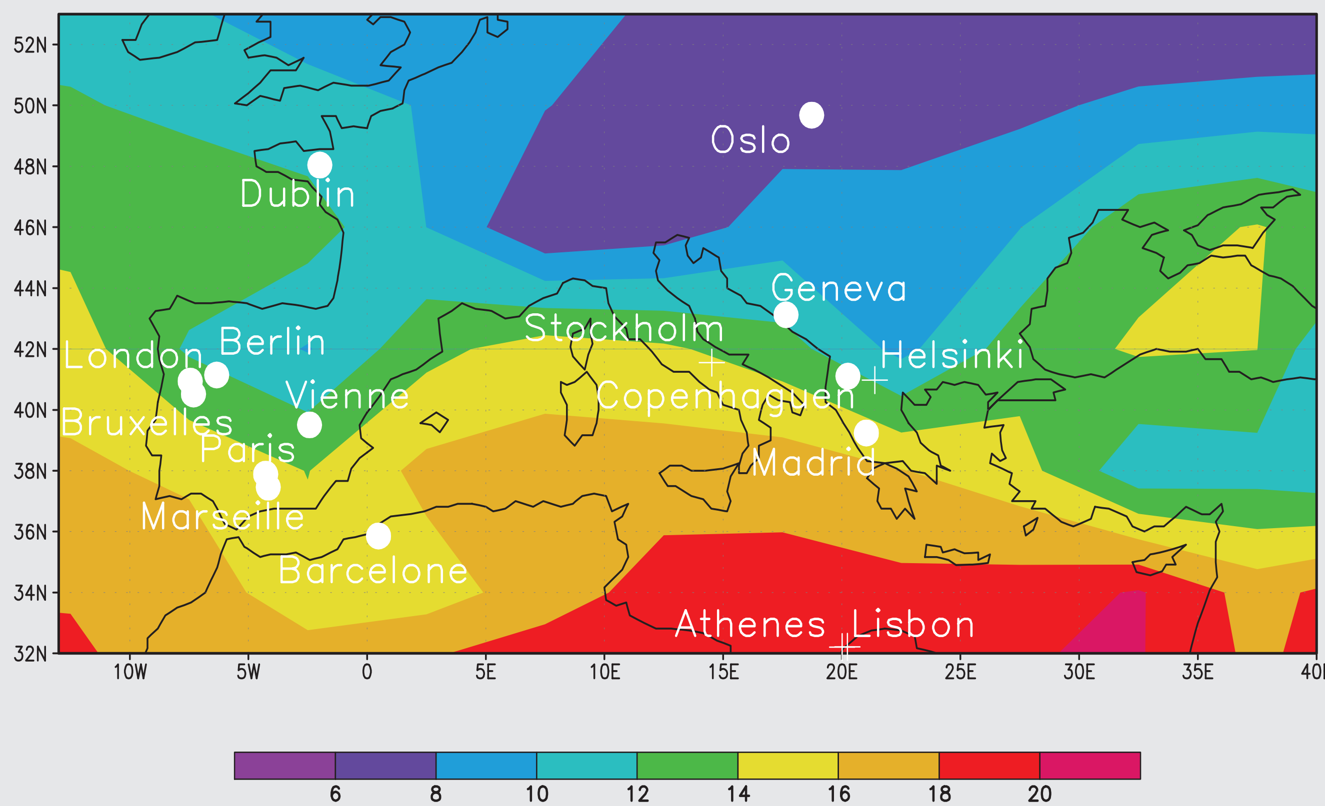
4

- Identify Adaptation Options
  - Expert Judgment
  - Spatial Analogues
- Assess Adaptation Options
  - Cost-Benefit Analysis
  - Risk Assessment
- Review Vulnerability and Adaptation Options

Spatial Analogues

Spatial analogues can also be used: in regions where new risks will appear, lessons can be learned from regions that already experience similar conditions. Mild-temperature cities, for instance, can learn from how high-temperature cities deal with heat waves; ideas can be drawn about more adequate architecture and urbanism, about transportation, about crisis management, and about the institutions that have been put in place to manage risks. Figure 4.14, for example, shows the projected temperatures at the end of the 21st century in Europe under the A2 scenarios. Cities are shown in the temperature zones, which will be appropriate to them at that time, with reference to the current geography. Paris, for example, at the end of the 21st century will have a climate similar to that currently experienced in cities in the south of Spain, such as Cordoba. For Paris to prepare, investigation of how Cordoba deals with high temperatures should take place.

Figure 4.14: Proposed Spatial Temperature Changes across Europe at the end of the 21st Century under the A2 Scenario



Source: Hallegatte et al., 2007

Assess Adaptation Options

When the list of adaptation options has been prepared, the next step is to prioritize between the various options.

Table 4.6 (see following page) outlines some of the points to bear in mind when choosing between adaptation strategies.

Cost-Benefit Analysis

Cost-Benefit Analysis (CBA) estimates and totals up the equivalent monetary value of the benefits and costs of projects to the sub-national region to establish whether they are worthwhile in the context of other criteria. It is only one among many economic decision-making methods. In particular:

- CBA requires a large amount of data both about the region, the interventions proposed, future climate change possibilities as well as future socio-economic possibilities
- CBA requires the probability of occurrence of all possible outcomes (see an illustration in Figure 4.13)
- CBA requires the ability to value losses that do not necessarily have a market price. Doing so involves judgment values and there are a number of economic tools and instruments to utilize for this purpose (e.g., how to value the loss of landscape? the loss of biodiversity? health impacts?)

One of the difficulties of CBA is that while the estimation of a number of components of benefits and costs is relatively straightforward, there are some for which measurement methods are unclear, difficult, and/or time-consuming. Some basic principles therefore apply for the effective application of CBA as a decision-making tool:

- Unit of measurement should be in a common basic denominator—usually in monetary terms
- The revealed preferences of stakeholders, including consumers and producers, must be taken into account. This is usually measured through their actual or likely behavior (based on observed information)
- Market choices are used as proxies for measuring benefits
- A counter-factual analysis is necessary (i.e., without an intervention/with an intervention)
- Double counting must be avoided
- Discounting is necessary but is fraught with political issues such as intergenerational issues

Risk Assessment

Risk assessment helps to prioritize vulnerabilities to climate change by pointing out the likelihood of occurrence. There are many different approaches to risk assessment. They relate to a selection of set return periods, or the average time interval before an event (or hazard) of similar magnitude occurs again. It is easier to set a type of event (say having more than 10% of a city flooded) and decide the maximum acceptable likelihood for this event (say 1% or once in 100 years). Of course, the acceptable likelihood will change depending on various parameters (population density, potential economic losses, population, risk aversion, etc.).

This type of assessment is often used for floods, where a large magnitude, low frequency event might be described as a 1 in 100 year event; whereas smaller events might be 1 in 10 year events. This knowledge helps to define the magnitude of an event to which an adaptation option must respond. Similarly, hazard

Table 4.6: Key Questions to Address when Considering an Adaptation Strategy

Question	Comment
1. What is the goal of the adaptation strategy? In the case of floods, for example, it is possible to: a. Maintain the current level of risk b. Reduce the level of risk despite climate change (if the risk is considered too high) c. Limit the increase in the level of risk due to climate change	
2. In the case of agriculture, for example, an adaptation strategy could: a. Aim to maintain the current type and level of production (e.g., through irrigation) b. Promote a transition to other crops, for example, ones that require less rainfall	Once the goals have been decided, efficiency criteria can be set for use in the review process.
3. Does the adaptation strategy take into account the varied timeframe over which climate hazards occur? a. "Adaptation gaps" (i.e., what needs to be done regardless of climate change) are immediate-term needs to ensure that the sub-national territory has adapted to the current climate (for example drainage systems that are adequate to cope with the current level of precipitation) b. Adaptation options that can be operationalized in the short-to medium-term: for example, plans to adapt to phenomena such as heat waves and droughts that will occur in the immediate- to medium-term c. Adaptation options that are needed in the context of managing issues that are likely to be problematic in the future, over different time scales— the next 5, 10, 15, 20, 30, 50 years and so on. For example, new urbanization plans to adapt to gradual sea level rise or industry developments in the context of likely decreasing viability of the effectiveness/productiveness of specific sectors as the climate changes	
4. Is the adaptation strategy a no-regret/low-regret solution? (This means one that yields immediate benefits even in the absence of climate change)	More efficient and effective water management, for example, may lead to cost reductions/savings and health benefits that promote a developmental improvement for the sub-national territory, regardless of climate change. Consideration must be given to all the unintended and likely unintended consequences of such strategies, including cross-sectoral implications. Promoting the use of air-conditioning, on the other hand, is not a no-regret/low-regret solution, as its use requires more intensive energy use, which in turn contributes to climate change.
5. Is the adaptation strategy flexible and reversible?	This is important given the uncertainty inherent in projecting future climate change – if parameters turn out to be different from what is currently projected, will it be possible to adjust the strategy accordingly? The strategy and measures must be robust to a range of potential climate change scenarios.
6. Consistency with other sub-national territory goals.	Sub-national planners in particular will be aware of the plethora of planning and developmental goals in their area. It is important to ensure that the adaptation strategy is consistent with other goals over the short, medium and long timescale. For example, does adaptation option have a positive or negative impact on poverty reduction? Does it fit into the short term planning goal for the sub-national territory? Does it fit in with nationally-promoted sustainable development strategies?

Source: Snover et al., 2007

levels relate to the return period: for example, what is the consequence of rain of 100mm per day at the 100 year return period, and what would the runoff consequences be? Assessment of hazards related to the event – in terms of which road section is flooded at the 100 year return period – is also helpful in deciding which adaptation options are most appropriate for an acceptable level of risk.

Economic impacts associated with certain levels of risk are also commonly used to prioritize adaptation options. From vulnerability relationships, it is possible to assess the potential direct losses: for example, what is the cost of the damages to the affected road section at the 100-year return period? This approach can be extended to also include indirect losses – for example, what is the cost of the welfare effects of the road damages caused by the 100 year flood, in terms of reduced economic productivity, health and social well-being impacts?

Once data on estimation of the risk (over several return periods) has been obtained, it can be compared with a pre-determined acceptable level of risk. Similarly, estimation of the total cost associated with a return period can be compared with a pre-determined acceptable one. Adaptation options can then be identified and assessed to determine how much they will cost to reduce the level of risk, or reduce the return period of exceeding losses. The pre-determined "acceptable" levels can be determined through a political process using various sources of information, including that provided by cost-benefit analysis.

Regular Review of Vulnerability and Adaptation Options

As was emphasized in Step 3, the process of vulnerability identification and mapping should be an ongoing process, with the exercise repeated at regular intervals to take into changing scientific projections of climate change and socio-economic development trajectories within the sub-national territory. Similarly, adaptation is a dynamic and reflexive process where a strategy evolves over time, rather than remaining static. It must co-evolve with many other policies and measures as well as reflect new information on vulnerability. The efficiency of many adaptation measures is still uncertain.

An adaptation strategy, and the various options that it contains, should thus also be subject to a review process. Efficiency indicators should be defined and monitoring data collected in order to review change over time. The steering group leading vulnerability mapping and adaptation within the sub-national territory should also schedule regular reviews that take into account co-costs and co-benefits. The suite of adaptation options being implemented may vary over time based on the results of the review process. For example, the adaptation approach may be comprised of 33%a, 33%b, and 33%c. Over time and based on review, the scope may change to 50%a, 50%b, and 0%c. Regular modification of the suite of adaptation options within the strategy will bring about the most effective results.

Additional Resources

Toolkits and Guidebooks for Undertaking Cost-Benefit Analysis

The technical and operational methods for undertaking cost-benefit analysis are widely documented in a number of sources. UNDP, World Bank, OECD and a number of other agencies have produced several toolkits and guidebooks on this subject. Although they may not have strictly been applied in the context of climate change adaptation projects, the underlying methodologies are the same.

- Gretel Gambarelli and Mike Toman (2009) *Economic Evaluation of Climate Change Adaptation Projects: Approaches for the agricultural sector and beyond,* World Bank. Available online at http://beta.worldbank.org/climatechange/content/note-7-resources

Toolkit for Designing Climate Change Adaptation Initiatives

- UNDP (2010) *Toolkit for Designing Climate Change Adaptation Initiatives.* Available online at http://www.undp-adaptation.org/projects/websites/docs/KM/PublicationsResMaterials/UNDP_Adaptation_Toolkit_FINAL_5-28-2010.pdf

Conclusion

This step provided a framework for evaluating changes in vulnerability to climate change under different socio-economic scenarios of development. It outlined decision-making tools that are helpful in prioritizing and assessing adaptation interventions (e.g., between sectors). The importance of stakeholder participation in the implementation of this step was emphasized. This is the last of the four steps addressed in this guidebook, which together provide the user with tools to map vulnerability and identify next steps, including adaptation options. This step concludes the instructional portion of the guidebook. It does not contain a case study, but offers a useful list of questions (see Table 4.6) to assist the user in prioritizing adaptation options. The following chapter provides a summary of the key points put forth in this publication.

PART III

CONCLUSION

Chapter 5 | Conclusion

Chapter 5
Conclusion

This guidebook is part of a series of publications UNDP is developing under the Territorial Approach to Climate Change (TACC) platform to provide guidance to regional governments on climate change planning. The series consists of a main publication, *A Primer on Integrated Climate Change Planning for Regional Governments*, which provides an overview on how to pursue low-emission climate-resilient development, and guidebooks like this one, which are topic specific and outline a process that is important to achieving a low-emission future.

The focus of this guidebook is on the process of identifying and mapping vulnerability to climate change at the sub-national level. It is based on the premise that the process of vulnerability mapping can be undertaken by sub-national planners without a climate background, by consulting the relevant stakeholders, accessing the appropriate existing information, and drawing on local and international expertise on the subject matter. There are more complex and high technology means to approach vulnerability mapping available, which may be useful to sub-national planners once they have undergone the vulnerability mapping process put forth in this publication. Box 5.1 (below) outlines a method, which provides a higher level of resolution.

This guidebook provides planners with the tools and resources they need to produce effective vulnerability and impact maps. In Part I, Chapter 1 provided an overview of the purpose and target audience of the guidebook, as well as the structure of the document. This chapter introduced a discussion on the impacts of climate change and described UNDP's Territorial Approach to Climate Change (TACC).

Chapter 2 set the context for the guidebook, introducing institutional mapping, discussing planning perspectives and timeframes and elaborating on the need for participatory stakeholder processes.

Box 5.1: Technical Assistance to the Mapping of Sub-National Territorial Vulnerabilities to Climate Change through ClimSAT

The ClimSAT platform was established by UNDP under the TACC Facility to identify, source and support countries with integrated, specialized high-technology inputs to assist with sub-national level vulnerability mapping. The objectives of the ClimSAT platform are:

- To support sub-national authorities with assessing anticipated effects of climate change on key sectors.
- To provide sub-national authorities with relevant information and technical services on conducting vulnerability mapping, including data analysis, expertise, and training services.

UNDP/ClimSAT is currently supporting sub-national authorities in Uruguay, Morocco, Albania, and Uganda. In 2010, services will be provided to Nicaragua, Senegal, Algeria, and Vietnam.

For further information, please email: territorial@undp.org.

Chapter 3 described the concept of vulnerability. Vulnerability is a function of exposure to climate hazards and perturbations, sensitivity to that hazard or perturbation, and the adaptive capacity of the sub-national territory.

The bulk of the process of vulnerability mapping was described in Part II, which went through the process of identifying current and future hazards and sensitivity under a range of scenarios, together with a largely qualitative approach to determining adaptive capacity. It also showed the importance of mapping this vulnerability, and tying it to places within the sub-national territory. To conclude, this section provided a framework for assessing and prioritizing adaptation interventions based on the sub-national planners mapping results. This is an important step within the process of setting up an Integrated Territorial Climate Plan.

Part III, the conclusion, offered a brief summary of the report and Part IV serves as resource section, which includes a glossary of key terms and a list of important websites.

PART IV

RESOURCES

Glossary of Terms

Unless otherwise stated, all definitions are taken from Tompkins et al., 2005.

Adaptation – Adjustment in natural or human systems in response to actual or expected climate changes or their impacts, so as to reduce harm or exploit beneficial opportunities.

Adaptive capacity – The potential or capability of a system to adjust its characteristics or behaviour to anticipate, cope with and respond to climate variability and change. (Adger, 2006)

Advocacy organization/group – An organization or group that works on behalf of, or supports, a cause or belief. Advocacy is an umbrella term for organized activism related to a particular set of issues.

Building code/regulations – Laws that control the construction or re-modeling of homes or other structures. They are regulations that are enforceable under the police powers of the state and locality controlling alterations, construction methods and materials, size and setback requirement, use and occupancy of all structures. Building codes have specific regulations covering all aspects of construction and are designed to maximize the health and welfare of the residents.

Climate change – Any change in climate over time, whether due to natural variability or because of human activity. (Burton and Huq, et al., 2004)

Climate variability – Variations in the mean state and other statistics (such as standard deviations, the occurrence of extremes, etc.) of the climate of all temporal and spatial scales beyond that of individual weather events. Variability may result from natural internal processes within the climate system (internal variability) or to variations in natural or anthropogenic external forcing (external variability). (Burton and Huq, et al., 2004)

El Niño – El Niño is a warm water current that periodically flows along the coast of Ecuador and Peru. This oceanic event is associated with a fluctuation of the inter-tropical surface pressure pattern and circulation in the Indian and Pacific Ocean, called the Southern Oscillation. This coupled atmosphere-ocean phenomenon is collectively known as the El Niño-Southern Oscillation. During an El Niño event, the prevailing trade winds and equatorial counter-current strengthens. This causes warm surface waters in the Indonesian area to flow eastward to overlie the cold waters of the Peru current. This event has great impact on the wind, sea surface temperature and precipitation patterns in the tropical Pacific. It has climatic effects throughout the Pacific region and in many other parts of the world.

Expert judgment – The opinion of experts used to elaborate scenarios and relate climatic variables with sector sensitivity and adaptive capacity.

Evaluation – The systematic collection and analysis of data needed to make decisions. Evaluations usually make use of data collected during monitoring, and are used to determine if a project meets its objective, and if continuation is required.

Geographical Information System - A computer system for capturing, storing, checking, integrating, manipulating, analyzing and displaying data related to positions on the Earth's surface. Typically a GIS is used for handling maps of one kind or another. These might be represented as several different layers where each layer holds data about a particular kind of feature (e.g., roads). Each feature is linked to a position on the graphical image of a map. Layers of data are organized to be studied and to perform statistical analysis (e.g., combining flood risk maps, with area development plans).

Greenhouse gas – A greenhouse gas is a component of the atmosphere that absorbs heat radiated by the Earth and subsequently warms the atmosphere, creating what is commonly known as the greenhouse effect. Common greenhouse gases include carbon dioxide, methane and water vapor.

Hazard – A physically defined source of potential harm, or a situation with a potential for causing harm, in terms of human injury; damage to health, property, the environment, and other things of value; or some combination of these. (CARICOM, 2003)

Hazard Mapping – The process of establishing where and to what extent particular phenomena are likely to pose a threat to people, property, infrastructure and economic activities. Hazard mapping represents the results of a hazard assessment on a map, showing the frequency/probability of occurrences of various magnitudes or durations.

Hazard Assessment – Hazard assessment refers to the process of assessing the size, severity, intensity and direction of a hazard. In the absence of sophisticated equipment, this process can be more a thought process than an engineering exercise. The thought process requires a consideration of the possible set of hazards that could affect an area and then a mental exploration of the impacts of those hazards. If resources are available, more technical assessments are possible, such as SLOSH models, which warn of the direction and height of storm surge associated with hurricanes.

Indicator - Indicators are quantifiable constructs that provide information either on matters of wider significance than that which is actually measured, or on a process or trend that otherwise might not be apparent. (Hammond et al., 1995)

Impact – Something that logically or naturally follows from an action or condition related to climate change or climate variability. (CARICOM, 2003)

Mal-adaptation – Is a faulty or inadequate adaptation and may include, for example, poorly designed responses to water level changes such as the promotion of development in high-risk locations.

Mitigation - A human intervention to actively reduce the production of greenhouse gas emissions (reducing energy consumption in transport, construction, at home, at work etc), or to remove gases from the atmosphere (sequestration).

Model - A model is a representation of reality. It is possible to use models for several purposes, including for the development of scenarios, to relate climatic variables to biophysical parameters and to assess changes in the provision of goods and services from the changes in biophysical parameters. (Tropical Forests and Climate Change Adaptation, 2006)

Monitoring – A mechanism or mechanisms to track progress in implementation of an adaptation strategy and its various components in relation to targets. (Burton and Huq, et al., 2004)

Resilience – Refers to three conditions that enable a social or ecological system to absorb change and not fundamentally fall apart. The conditions are: ability to self-organize, ability to buffer disturbance and capacity for learning and adapting.

Risk (climate related) – the result of the interaction of physically defined hazards with the properties of the exposed systems – i.e., their sensitivity or vulnerability. Risk can also be considered as the combination of an event, its likelihood, and its consequences – i.e., risk equals the probability of climate hazard multiplied by a given system's vulnerability. (Burton and Huq, et al., 2004)

Risk Management – The systematic application of management policies, procedures, and practices to the tasks of analyzing, evaluating, controlling and communication about risk issues. (Burton and Huq, et al., 2004)

Risk Management Plan – A risk management plan summarizes the proposed risk management approach for a project, programme or policy.

Scenario - Representation of the future state of a system, including a projection of selected variables that determine that state.

Sector – A part or division, such as the economy (e.g., the manufacturing sector or the services sector), or the environment (e.g., water resources or forestry). (Burton and Huq, et al., 2004)

Siltation – A build-up of silt (fine particles or earthy matter), suspended in rivers or other bodies of water which is then deposited in channels, reservoirs, estuaries, harbors, etc. It enters watercourses as a side effect of soil erosion and water run-off (e.g., because of deforestation).

Stakeholders – Those who have interests in a particular decision, either as individuals or as representatives of a group. This includes people who can influence a decision as well as those affected by it. Decision makers are also stakeholders.

Strategy – A broad plan of action that is implemented through policies and measures. Strategies can be comprehensive (i.e., focusing on national, cross sectoral scales) or targeted (i.e., focusing on specific sectors, regions or measures). (Burton and Huq, et al., 2004)

Sustainable Development – A widely used and accepted international term that is defined as: "development which meets the needs of the present without compromising the ability of future generations to meet their own needs."

Uncertainty – An expression of the degree to which a value (e.g., the future state of the climate system) is unknown. (Burton and Huq, et al., 2004)

Vulnerability – the degree to which an individual, group or system is susceptible to harm due to hazards to a hazard or stress, and the (in)ability to cope, recover, or fundamentally adapt (become a new system or become extinct).

Vulnerability Analysis – this identifies who and what is exposed and sensitive to external impacts. A vulnerability analysis starts by considering the factors that make the people of an environment susceptible to harm, i.e., access to natural and financial resources; ability to self-protect; support networks and so on.

Vulnerability Assessment - Identifies who and what is exposed and sensitive to change. A vulnerability assessment starts by considering the factors that make people or the environment susceptible to harm, i.e., access to natural and financial resources; ability to self-protect; support networks and so on. It will be helpful to think through some of the 'symptoms' of vulnerability reflected in certain sectors.

List of Websites

Alliance of Small Island States (AOSIS)
http://www.sidsnet.org/aosis/index.html
A coalition of small island and low-lying coastal countries that share similar development challenges and concerns about the environment, especially their vulnerability to the adverse effects of climate change.

Asia-Pacific network
http://www.ap-net.org/index.html
A knowledge based resource for the Asia-Pacific region on climate change issues. It provides: a platform for policy dialogues and consultation with the region; access to the latest information and data on climate change issues and development focusing on the Asia-Pacific; support for capacity building for developing countries in the region. The following link will take you to the Adaptation documents in the library. For publications concerning adaptation to climate change in the region:
http://www.ap-net.org/database/library/09.html

Assessments of Impacts and Adaptations to Climate Change (AIACC) in Multiple Regions and Sectors
http://www.aiaccproject.org/aiacc.html
A global initiative developed in collaboration with the UNEP/WMO Intergovernmental Panel on Climate Change (IPCC) and funded by the Global Environmental Facility to advance scientific understanding of climate change vulnerabilities and adaptation options in developing countries. AIACC aims to enhance the scientific capacity of developing countries to assess climate change vulnerabilities and adaptations and generate and communicate information useful for adaptation and action.

Capacity-building for the Development of Adaptation Measures in Pacific Island Countries (CBDAMPIC)
http://www.sprep.org.ws/climate/documents/First_Six_Monthly_Report-CBDAMP.pdf
This project is being executed by the South Pacific Regional Environmental Programme (SPREP) for the Canadian International Development Assistance in the Cook Islands, Fiji, Samoa and Vanuatu.

Centre International de Recherche sur l'Environnement et Le Developpement (CIRED)
www.centre-cired.fr (in French)
The Centre International de Recherche sur l'Environnement et Le Developpement (CIRED) undertakes research related to climate change, including economic modeling and integrated assessments.

Climatic Research Unit
http://www.cru.uea.ac.uk/cru/projects/magicc/
The Climatic Research Unit is based in the School of Environmental Sciences at the University of East Anglia, Norwich, UK. It is widely recognized as one of the world's leading institutions concerned with the study of climate change. It provides a good source of much climate data, information about climate change and links to information sources based around the world. The unit also provides information about and access to the climate models MAGICC and SCENGEN.

Covenant of Mayors
http://www.eumayors.eu/
The European Union (EU) is leading the global fight against climate change, and has made it a top priority. Its ambitious targets are spelled out in the EU Climate Action and Renewable Energy Package, which commits Member States to curb their CO2 emissions by at least 20% by 2020. Signatories of the Covenant of Mayors contribute to these policy objectives through a formal commitment to go beyond this target through the implementation of their Sustainable Energy Action Plan.

CRiSTAL: Community-based Risk Screening Tool – Adaptation and Livelihoods
A well known and useful tool for integrating adaptation, CRiSTAL is designed to assist project planners and managers with integrating risk reduction and climate change adaptation into livelihoods projects. Developed by the International Institute for Sustainable Development (IISD) in partnership with the International Union for the Conservation of Nature (IUCN), Stockholm Environment Institute (SEI) and Inter-cooperation, the tool is designed to help users to:

- systematically understand the links between local livelihoods and climate risks;
- assess a project's impact on community level adaptive capacity;
- and make adjustments to improve a project's impact on adaptive capacity.

The tool is highly compatible with the CVCA. The information gained from the CVCA can feed directly into CRiSTAL, which facilitates analysis of implications for project activities. The CRiSTAL tool can be downloaded at:
http://www.cristaltool.org

In addition to CRiSTAL, there are a number of other tools and methodologies available to support integration of adaptation into development programs at both the project level and strategic planning level. For a summary of climate adaptation tools, see:
http://www.iisd.org/pdf/2007/sharing_climate_adaptation_tools.pdf

The Global Environment Facility
http://gefweb.org/index.html
The Global Environment Facility (GEF) helps developing countries fund projects and programmes that protect the global environment. GEF grants support projects related to biodiversity climate change, international waters, land degradation, the ozone layer and persistent organic pollutants.

GRASS GIS
http://grass.itc.it/
Geographic Resources Analysis Support System (GRASS) is a freely-available GIS software system created by the Open Source Geospatial Foundation. The software is widely used by companies, governments, and academic entities around the world, and as well as the free download, the website contains tutorials on how to use the software.

ICLEI-Local Governments for Sustainability
http://www.iclei.org/
ICLEI-Local Governments for Sustainability is an international association of local governments, as well as national and regional local government organizations who have made a commitment to sustainable development. ICLEI provides technical consulting, training and information services to build capacity, share knowledge, and support local government in the implementation of sustainable development at the local level. Their aims include support for the implementation of the Rio Conventions, including the UNFCCC.

The Institute of Development Studies (IDS)
http://www.ids.ac.uk/go/browse-by-subject/climate-change
Website includes useful briefs and analysis on climate change adaptation issues.

Intergovernmental Panel on Climate Change (IPCC)
http://www.ipcc.ch/
The role of the IPCC is to assess on a comprehensive, objective, open and transparent basis the scientific, technical and socio-economic information relevant to understanding the scientific basis of risk of human-induced climate change, its potential impacts and options for adaptation and mitigation.

The most recent Fourth Assessment Report is available online:
http://www.ipcc.ch/publications_and_data/publications_and_data_reports.htm#1

The IPCC also runs a Data Distribution Centre, which offers access to baseline and scenario data. It also provides technical guidelines on the selection and use of different types of data and scenarios in research and assessment. The DDC is designed primarily for climate change researchers, but materials contained on the site may also be of interest to educators, governmental and non-governmental organizations, and the general public:
http://www.ipcc-data.org/

International Institute for Environment and Development (IIED) - Climate Change Group
http://www.iied.org/CC/index.html
The climate change group of the IIED has been leading the field on adaptation to climate change issues since its inception as a discrete programme in 2001 and generates commentary and analysis on climate change.

International Institute for Sustainable Development (IISD)
http://www.iisd.org/climate/vulnerability/
IISD works within Canada and internationally to increase understanding of effective responses to the complex socio-economic and environmental impacts of climate change; to develop tools and processes to facilitate these responses; and to encourage integration of adaptation considerations into routine decision-making. The website provides help tools and policy analysis on climate change.

International Research Institute for Climate and Society (IRI) LDEO Climate Data Library

http://iridl.ldeo.columbia.edu/index.html

The IRI/LDEO Climate Data Library contains over 300 free datasets from a variety of earth science disciplines and climate-related topics that can be accessed, downloaded in a variety of formats (including GIS-compatible), and used to create visual representations of data, including animations.

The Linking Climate Adaptation (LCA) Network

http://community.eldis.org/.599266eb/

The Linking Climate Adaptation (LCA) Network is an online community of over 900 practitioners, stakeholders, researchers and policy-makers exchanging information on climate adaptation research and practice around the globe via the Network email list. This space on Eldis Community acts as an archive for messages sent to the network via the email list and as a document store. Membership of the Network is free.

Maghreb project (Projet Maghrébin sur les Changements Climatiques)

http://www.ccmaghreb.com/Projet_RAB_cc/mainfrab.htm (in French)

This collaborative regional project (covering the Maghreb region, i.e., Algeria, Morocco, Tunisia) explores policy responses to climate change vulnerability with a view to guiding the region toward reduced impacts and greater adaptive capacity.

Météo-France website

www.meteo.fr (in French)

France's major weather and climate website provides national and regional forecast information as well as global climatological data.

National Adaptation Plans of Action (NAPAs)

www.undp.org/napa.htm

http://unfccc.int/national_reports/napa/items/2719.php

NAPAs have been established to address the urgent and immediate national needs of Least Developed Countries (LDCs) for adapting to the adverse impacts of climate change and for preparation of National Communications to the UNFCCC. NAPAs provide a process for LDCs to identify priority activities to respond to climate change. The NAPA takes into account existing coping strategies at the grassroots level, and builds upon them to identify priority activities. Prominence is given to community-level input as an important source of information, recognizing that grassroots communities are the main stakeholders.

The Nairobi Work Programme on impacts, vulnerability and adaptation to climate change

http://unfccc.int/adaptation/sbsta_agenda_item_adaptation/items/3633.php

The Nairobi Work Programme is a 5-year programme (2005-2010) implemented by Parties to the UNFCCC, intergovernmental and non-governmental organizations, the private sector, communities and other stakeholders. Its objective is to assist all Parties, in particular developing countries, including the LDCs and Small Island Developing States to:

- improve their understanding and assessment of impacts, vulnerability and adaptation to climate change;
- make informed decisions on practical adaptation actions and measures to respond to climate change on a sound scientific, technical and socio-economic basis, taking into account current and future climate change and variability.

The Nairobi Work Programme has developed a compendium on methods and tools as well as an adaptation practices interface.

Network of Regional Governments for Sustainable Development

http://www.nrg4sd.org/

The Network of Regional Governments for Sustainable Development was launched in 2002 at the World Summit for Sustainable Development in Johannesburg. It is a membership organization that represents regional governments at the global level and promotes understanding, collaboration and partnerships in sustainable development. Climate change is among the policy areas promoted by the organization.

The New Scientist

www.newscientist.com/channel/earth/climate-change

The website of the New Scientist magazine includes recent climate change news, background information, weblinks to informative resources and answers to frequently asked questions on climate change.

PICCAP (Pacific Islands Climate Change Assistance Programme)

http://www.gefweb.org/Outreach/utreach-PUblications/Project_factsheet/Asia_Pacific-paci-3-cc-undp-eng.pdf

PICCAP is a US$3.2 million, 10 Pacific Island country programme enabling activity on climate change. PICCAP commenced operation in July 1997. The primary aim of PICCAP is to build, enhance and strengthen national capacities in Pacific Island countries to undertake studies and report to the United Nations

Framework Convention on Climate Change (UNFCCC). Through PICCAP, participating countries have completed Greenhouse Gas Inventories, Mitigation Analysis, Vulnerability and Adaptation Assessment and National Communications.

The Red Cross/Red Crescent Climate Centre

http://www.climatecentre.org/index.php?page=news_ext&pub_id=85&type=4&view=more

The Red Cross / Red Crescent Climate Centre is the reference centre on climate change of the Red Cross / Red Crescent family. The Climate Centre supports the Red Cross and Red Crescent Movement to understand and address the humanitarian consequences of climate change and extreme weather events. The Centre's main approach is to raise awareness; advocate for climate adaptation and disaster risk reduction (within and outside the Red Cross and Red Crescent); analyze relevant forecast information on all timescales; and integrate knowledge of climate risks into Red Cross Red Crescent strategies, plans and activities.

The Royal Society

http://www.royalsoc.ac.uk/page.asd?id=2986

The Royal Society provides a guide to facts and fictions about climate change. This website examines twelve misleading arguments put forward by the opponents of urgent action on climate change and highlights the scientific evidence that exposes their flaws.

The Special Climate Change Fund (SCCF)

http://unfccc.int/cooperation_and_support/funding/special_climate_change_fund/items/2602.php

The SCCF under the UNFCCC will finance projects related to adaptation; technology transfer and capacity building; energy, transport industry, agriculture, forestry and waste management; and economic diversification.

Tyndall Centre for Climate Change Research

http://www.tyndall.ac.uk

The Tyndall Centre is a national UK centre which brings together scientists, economists, engineers and social scientists, who together are working to plan for climate change. The Tyndall Centre has a research programme focused on adaptation to climate change:

http://www.tyndall.ac.uk/research/transition-period/resilience

UK Climate Impacts Programme (UKCIP)

http://www.ukcip.org.uk/

UKCIP was set up in 1997. It provides guidance to UK climate change stakeholders on how to prepare for and respond to climate change. There are many resources available on the web site to help individuals and companies adapt, these include an 'adaptation wizard', climate change scenarios and regional impact and vulnerability assessments. UKCIP shares this information with organizations in the commercial and public sectors to help them prepare for the impacts of climate change.

UK Met Office and Hadley Centre

http://www.metoffice.com/index.html

http://metoffice.com/research/hadleycentre/index.html

The Met Office is a leading provider of environmental and weather-related services including sources of information about climate change. The Hadley Centre for Climate Prediction and Research is part of the Met Office, providing a focus on climate change science and widely used climate models.

United Nations Development Programme (UNDP)

http://www.undp.org/gef/undp-gef_focal_areas_of_action/sub_climate_Change.html

UNDP is the UN's global development network, an organization advocating for change and connecting countries to knowledge, experience and resources to help people build a better life. UNDP provides extensive information relating to climate change.

United Nations Framework Convention on Climate Change (UNFCCC)

http://unfccc.int

The UNFCCC is a global treaty that commits signatories to take collective responsibility for climate change and to take action to address the problem. It calls for the "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system." It was signed at the 1992 Earth Summit in Rio de Janeiro. There are several sections pertaining to adaptation:

http://unfccc.int/adaptation/items/2973.php

United Nations International Strategy for Disaster Reduction (UNISDR)

http://www.unisdr.org/

The International Strategy for Disaster Reduction is a strategic framework, adopted by UN member states in 2000, that aims to coordinate the efforts of partners to reduce disaster losses and build resilient nations and communities. It is also the focal point for implementation of the Hyogo Framework for Action, a ten-year plan to protect lives and livelihoods against disaster losses that was signed by 168 governments in 2005. One of their current campaigns is entitled "Making Cities Resilient", which focuses on raising political commitment to disaster risk reduction and climate change adaptation among local governments and mayors (http://www.unisdr.org/english/campaigns/campaign2010-2011/). The campaign was launched at the first World Congress on Cities and Adaptation to Climate Change in Bonn, Germany, 28-30 May 2010.

Vulnerability and Adaptation Resource Group (VARG)
http://www.climatevarg.org/
As an informal network of institutions, VARG facilitates the integration of climate change adaptation in the development process through the sharing, assessment, synthesis and dissemination of existing knowledge and experience. The target audience is developing countries, the UNFCCC process, civil society and development agencies. The website provides links to a number of documents on climate change provided by different institutions and useful links to information about:

- Climate variability, extremes and change: scientific background on vulnerability and adaptation
- The political context of climate change
- Development, poverty and climate change
- Adaptation projects and initiatives

WeADAPT
http://www.weadapt.org/
An online platform that offers a range of innovative tools to help users create a community of practice working together on adaptation by accessing, sharing and synthesizing knowledge on adaptation. WeADAPT provides support for adapting to climate change, both on its own and as part of broader development processes, by pooling expertise from a wide range of organizations that contribute to adaptation science, practice and policy. WeADAPT provides guidance by pooling expertise from a wide range of organizations that contribute to adaptation science and practice.

The World Conservation Union (IUCN)
http://www.iucn.org/themes/fcp/expereience_lessons/climate_icun_initiative.htm
IUCN builds bridges between governments and NGOs, science and society, local action and global policy. Its mission is "to influence, encourage and assist societies throughout the world to conserve the integrity and diversity of nature and to ensure that any use of natural resources is equitable and ecologically sustainable." This link offers access to some interesting publications concerning climate change adaptation and ecosystems, water management, forests, nature, etc.

World Health Organization
The World Health Organization is the United Nations special agency for health. They have information relating health to climate change:
http://www.who.int/topics/climate/en/
http://www.who.int/globalchange/climate/en/

These pages provide access to much information and a number of publications concerning the impacts of climate change on health and information about adaptation.

World Mayors Council on Climate Change
http://www.iclei.org/index.php?id=7192
The World Mayors Council on Climate Change is an alliance of local government leaders advocating an enhanced recognition and involvement of mayors in multilateral efforts addressing climate change and related issues of environmental sustainability. The council was founded in 2005 and currently includes over 30 members (mayors and equivalent leaders of municipal levels of government.

World Meteorological Association
http://www.wmo.ch/index-en.html
http://www.wmo.ch/nino/ninoi.html (Information about El Niño)
This website provides much background information about the climate system. In the specific case of weather-related natural disasters, WMOs programmes provide the vital information for the advance warnings that save many lives and reduce damage to property and the environment.

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