Sustentabilidade em Debate

Governing climate change: urbanization, vulnerability and challenges for the northern coast of the state of São Paulo, Brazil

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RESUMO

Palavras-chave: mudanças climáticas, vulnerabilidade, adaptação, litoral norte Paulista, Brasil

Este artigo discute a vulnerabilidade do Litoral Norte do Estado de São Paulo, Brasil, em relação às mudanças climáticas. Baseando-se em uma revisão da literatura específica e num estudo de caso que englobou a análise de documentos oficiais, dados secundários e entrevistas semi-estruturadas com gestores e representantes da sociedade civil, o artigo busca contribuir com o debate das mudanças climáticas nos municípios costeiros brasileiros por meio de uma proposta conceitual e analítica para investigar e discutir os múltiplos processos e as interações entre mudança ambiental, socioeconômica e climática nesses espaços. Os resultados da pesquisa mostram que a vulnerabilidade dos municípios do Litoral Norte Paulista é amplamente dependente de seus fatores históricos e contextos socioeconômicos. Nesse sentido, as transformações trazidas para a região nas últimas quatro décadas por meio de um intenso processo de urbanização turística e crescentes atividades industriais aprofundaram problemas sociais e ambientais, aumentando a vulnerabilidade não só da região como um todo, como também de grupos específicos, em relação à variabilidade e mudanças do clima. A sobreposição de processos socioambientais e os diferentes níveis da problemática da mudança do clima colocam grandes desafios para a governança e as instituições presentes nesses municípios que têm falhado em responder às causas dessa situação de vulnerabilidade, deixando claro que são pouco capazes de responderem, sozinhos, ao crescente risco de impactos das mudanças climáticas.

ABSTRACT

Key-words: climate change, vulnerability, adaptation, northern coast São Paulo, Brazil

This paper examines the climate change vulnerability of the Northern Coast of the State of São Paulo (*Litoral Norte Paulista*), Brazil. Based on a literature review and a case-study encompassing the analysis of policy documents, secondary data and semi-structured interviews with policymakers and civil society representatives, it aims to provide a useful way to examine the multiple and overlapping processes of environmental, social-economic and climatic change in this region. By analyzing its vulnerability, the paper argues that the degree to which these cities are vulnerable to climate change is largely determined by the broader historic and socio-economic contextual factors. The finding indicates that the social, economic and cultural changes brought by the last four decades of intense process of urbanization, tourism exploitation and increasingly economic activities have deepened social and environmental problems, increasing the vulnerability of particular groups and the region as a whole to climate variability and change. The cross-scale nature of the problems and the cross-level interactions of these processes pose significant challenges for the governance structures and institutions on the region that fail to address the root causes of vulnerability, highlighting the municipalities' insufficiency to address the consequences of a changing environment and climate.

1 Introduction

Coastal zones are among the most exploited areas worldwide due to their abundance in natural resources that can provide humans with many ecosystem services that are important to support livelihoods and economic activities (CROSSLAND et al., 2005; NICHOLLS et al., 2007). There is a long history of human settlement in coastal zones, but until the first half of the twentieth century the level of disturbance to natural process did not appear to be critical (MEA, 2005). However, the increasing attraction of people, businesses and industries to these places have revealed that they are also subject to numerous threats, some of which are expected to become more serious due to a changing climate (KRON, 2008; SATTERTHWAITE, 2009). Additionally, unprecedented rates of urbanization and population growth without adequate planning have become major drivers of environmental change in these areas, particularly in the developing world. Not surprisingly, the continuing use of coastal areas has led to a variety of environmental degradation, *habitat* destruction and pollution, raising the public awareness in the terms of the vulnerability of coastal zones (CROSSLAND et al., 2005; KRON, 2008; REVI, 2008).

In Brazil, one of the fast growing developing countries, the situation is not different. The country has many of its cities located on a coastline of more than 8,600 km that encompasses around 20% of the total Brazilian population distributed within 17 states, 395 municipalities and 16 metropolitan regions[1] (ZAMBONI & NICOLODI, 2008; NEVES & MUEHE, 2008). The agglomeration of population along the Brazilian coast has been intensifying in the last decades due to three main drivers of development patterns: urbanization, industrialization and tourism exploitation (BORELLI, 2008; ZAMBONI & NICOLODI, 2008).

Increasing scientific evidence suggests that global warming due to the combination of anthropogenic emissions of greenhouse gases (GHG) and natural variability is having a discernible effect on the Earth's climate (STEFFEN et al., 2004; IPCC, 2007). These effects are expected to intensify a range of climatic aspects, including acceleration in global sea-level rise (SLR), which can have critical impacts on coastal areas in general (NICHOLLS et al., 2007), especially in Low Elevation Coastal Zones (LECZ) (MCGRANAHAN et al., 2007). Future SLR has been already recognized as one of the more certain consequences of climate change through the twenty-first century (CROSSLAND et al., 2005; NICHOLLS et al., 2007), posing new risks to coastal socio-ecological systems that face continuous stresses (SOUZA, 2010). Likewise, it is not only SLR, but also the possibility of more intense storms and extreme weather events on the coasts that are of particular interest of society as many coastal cities are also naturally exposed to environmental hazards (CROSSLAND et al., 2005). KRON (2008) goes further by arguing that coastal zones are among the riskiest places on the planet.

Although there is mounting concern over climate change and its impacts at the global and national levels, coastal municipalities in Brazil (and in most of the global South) did not receive the adequate attention as they usually face a number of other more urgent problems such as development deficits (MARTINS & FERREIRA, 2011a; 2011b; FERREIRA et al., 2011), environmental degradation and the impacts of short-term climate variability and extremes (KRON, 2008; REVI, 2008; TCU, 2009; WIGLEY, 2009, MENDONÇA, 2010). In the State of São Paulo, the largest Brazilian state in terms of population and

economic activities (FERREIRA et al., 2011), the poor communities located in coastal zones are among those who bear most of the harmful effects of natural hazards in general[2], which include flooding, loss of coastal lands, coastal erosion and landslides (SOUZA, 2003; 2009; 2010; MENDONÇA. 2010; VIEIRA et al., 2010). Current responses to climate variability and change are traditionally being addressed more as post-disaster assistance rather than disaster preparedness and long-term adaptation as the other necessary measures to enhance the adaptive capacity (SATTERTHWAITE, 2009; MARTINS & FERREIRA, 2011b).

In this sense, it is important not only to investigate and understand the vulnerability of Brazilian coastal cities, but also elsewhere in the developing world, as an effort to improve their current and future adaptive capacity to climatic events. Understanding the vulnerability and identifying potential adaptive measures have been advocated to be one of the most appropriate strategies to increase resilience to the potential impacts of unavoidable climate change (ADGER et al., 2005; SMIT & WANDEL, 2006; REVI, 2008; ERICKSEN et al., 2011).

This paper examines the current and future vulnerability to climate variability and change as well as it discusses the potential for adaptation in the four coastal cities located on the Northern Coast of the State of São Paulo, Brazil to address climate risks, with the objective of integrating appropriate risk management strategies into the existing urban development and planning within the context of sustainable development. More specifically the study seeks also to identify and examine the contextual vulnerability of this region, focusing on its main characteristics, drivers of change and capacity to cope and respond to the impacts of climate variability and change. Building upon findings from a broader research endeavor, the municipalities of the were considered as being part of a single region with common socio-economic and environmental characteristics; as a result, specificities or details about particular cities on the Northern Coast have been overlooked with the emphases put on the regional dynamics, trends and challenges.

In terms of the applied methodology, the paper builds upon three main research activities. First, a literature review on climate change vulnerability, adaptation and impacts has been performed to understand the broader governance challenges for urbanized coastal areas (see MARTINS & FERREIRA, 2011a; 2011b; FERREIRA et al., 2011 for details). Second, analyses of official documents (*i.e.* environmental assessments; municipal masterplans; climate change projections), and secondary data (*e.g.* IBGE; SEADE; INPE) have been carried out to collect and organize information about the region's history, policy and contextual factors. Third, 12 semi-structured interviews with policymakers (*e.g.* Municipal Secretariat for Urban Planning/Administration; Municipal Secretariat for the Environment; Civil Defense Department/Coordination) and civil society representatives (*e.g.* non-government and community-based organizations) were undertaken in two particular occasions as part of a larger fieldwork and case-study research conducted in the four municipalities between November 2009 and July 2010.

The research shows that while climate variability and change is expected to impact the region, its effects and responses will be influenced by the broader setting of policy decisions and socio-economic changes that have been transforming the region in the last four decades. The paper thus illustrates the need to understand local and regional situations building upon a comprehensive analysis of the governance landscape and how it

influences not only the vulnerability for current and future impacts of climate change but also the potential for implementing adaptations.

2 Conceptualizing Climate Change Vulnerability in the Context of Multiple Stressors

2.1 Defining Vulnerability

Recent work and scholarship among climate change researchers has shown an emphasis on vulnerability and the extent to which social-ecological systems can adapt to and thereby deal with different types of change (CUTTER, 1996; PELLING, 2003; TURNER et al., 2003; SMIT & WANDEL, 2006). In this sense, an exposed unit (*e.g.* ecosystem, watershed, household, city, region or country) is vulnerable when climate disturbance and change not only result in losses but also when it lacks the capacity to regain a trajectory of social-environmental development, thus potentially creating a negative spiral of increasing loss (EAKIN & LUERS, 2006; SMIT & WANDEL, 2006). People and communities are experiencing a number of threats, such as social and economic changes, climate change and environmental degradation (UNEP, 2009). These changes do not occur in isolation and often reflect broader changes that may amplify or reduce the importance of the environmental and climate challenges (PELLING, 2003; LEICHENKO & O'BRIEN, 2008).

Vulnerability thus refers to the potential of a system to be harmed by an external stress, either a hazard or a threat (risk) (PELLING, 2003). While the risk includes exposure to external hazards over which people and places have little or no control, vulnerability is a measure or a characterization of the capacity to manage these dangers without any loss of well-being that might be potentially irreversible in the long run (EAKIN & LUERS, 2006; ERIKSEN et al., 2011). It may be defined as a function of *exposure*, *sensitivity* to impacts and the ability or lack of ability to cope or adapt that can be also termed its *adaptive capacity*. The exposure can be to hazards such as floods, landslides and SLR, but also conflict, lack of adequate housing, or underlying socio-economic, institutional and environmental conditions (PELLING, 2003; SATTERTHWAITE, 2009). The severity of the impacts not only depends on the exposure, but also on the sensitivity of the specific unit exposed and on the capacity to cope or adapt (adaptive capacity) (PELLING, 2003). In this sense, the idea of vulnerability may also be considered an important extension of traditional risk analysis, which for decades focused primarily on natural hazards (TURNER et al., 2003).

When focusing on climate change, vulnerability can be described as the degree to which a system is susceptible to or unable to cope with, the adverse effects of climate change, including climate variability and extremes (TURNER et al., 2003; SMIT & WANDEL, 2006; see also **Figure 1** for clarification). It is also a function of the character, magnitude and rate of climate variation to which people and the environment are exposed, their sensitivity and adaptive capacity (TURNER et al., 2003; SMIT & WANDEL, 2006). Exposure could include geographical location, especially high exposure to risks (*i.e.* people living in disasters-prone areas). Sensitivity and adaptive capacity are context-specific and vary from country to country, from community to community, among social groups and individuals, and through time (ADGER et al., 2005; SMIT & WANDEL, 2006; EAKIN & LUERS, 2006).

PELLING (2003) provides a systematic discussion of the vulnerability of cities in the context

of natural hazards. According to this author a population could be considered sensitive based on their overall level of social development. In this context, adaptive capacity depends on the availability of resources that could support responses to threats and exposures (*e.g.*, financial, human, political, technical resources; functioning community networks, early warning systems, legislation and norms, *etc*). Adaptive capacity of the communities is often depleted when they are in illegal settlements, conflict zones, or areas with weak law enforcement (ADGER et al., 2005; SATTERTHWAITE, 2009).

Finally, there is a very strong relationship among exposure to climate impacts, general adaptive capacities and overall ecosystem degradation (PELLING, 2003). Specifically, climate change may exacerbate ecosystem degradation (*e.g.* land-cover

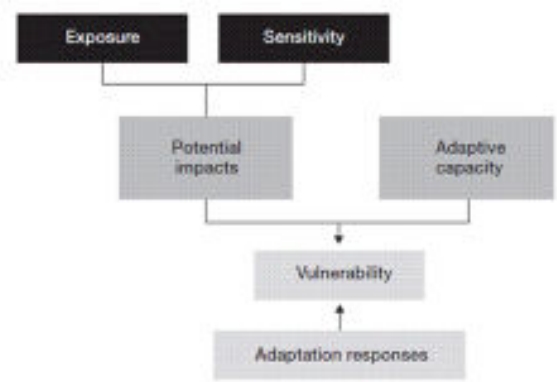


Figure 1-Components of vulnerability to climate change
Source: Adapted from ALLEN CONSULTING (2005)

change, over-exploitation, pollution) causing substantial changes in the structure and function of ecosystems so they are no longer able to provide ecosystem services such as fresh water, coastal flood protection, slope stability and erosion control (SATTERTHWAITE, 2009; SOUZA, 2010). On the other hand, ecosystem degradation may often trigger other disasters and reduce the capacity of nature and people to withstand impacts of climate change and disasters, because degradation limits the system's ability to buffer against floods, heavy rain and SLR (PELLING, 2003; UNEP, 2009). Building on that, in order to analyze the vulnerability, it is necessary to understand the context of the system and how they are impacted by the multiple stressors.

2.2 Assessing Vulnerability

The point of departure for most vulnerability and adaptation assessments lies in the basic question "*vulnerable to what?*". When answering this question, scholars argue that attention should be paid to trying to investigate the most important causes of vulnerability, identifying where and how different drivers and pressures interact and lead to undesirable situations and the available capacities to cope with risks and threats (CUTTER, 1996; TURNER et al., 2003; PELLING, 2003; EAKIN & LUERS, 2006). Usually this type of investigation shows that processes such as global environmental change, including climatic changes, are not occurring in isolation of one another, or in isolation of other drivers and pressures (see LEICHENKO & O'BRIEN, 2008; ERIKSEN et al., 2011). A community that is settled in informal, illegal and/or risk-prone areas, lacking assets and resources, will have fewer capacities to cope with severe climatic events, which could include floods, landslides or accelerated SLR (PELLING, 2003; ADGER et al., 2005). Similarly, households that are heavily in debt may not allocate enough resources to regular inspections or improvement in house structures. Therefore, they are more susceptible to potential impacts of climatic events than a well-prepared family (PELLING, 2003; ERIKSEN et al., 2011).

As vulnerability is a dynamic concept and stressors on the human-environment system are constantly changing, as are the available assets

and capacities (EAKIN & LUERS, 2006; SMIT & WANDEL, 2006; LEICHENKO & O'BRIEN, 2008), vulnerability assessments should be employed not only to identify areas of *unsustainability*, but also specific capacities and potential responses of vulnerable people and places in the context of exposure in particular locations (TURNER et al., 2003; ERIKSEN et al., 2011). However, research shows that it is challenging to take into account whole system perspectives, with driving forces and pressures often interacting on complex landscapes, operating on a national or even global scale (LEICHENKO & O'BRIEN, 2008; ERIKSEN et al., 2011).

In order to overcome this shortcoming, one strategy that was applied to assess the vulnerability under these conditions has been the adoption of the **D**rivers-**P**ressure-**S**tate-**I**mpacts-**R**esponse (DPSIR) framework, among others, by the United Nations Environment Program Global Environment Outlook (UNEP/GEO) reports. This framework seeks to connect root causes (*drivers* and *pressures*), environmental and climate outcomes (*State* and *Impacts*) to the activities that shape the broader governance setting (policies and decisions) in terms of *responses*. Integrating these normative principles of vulnerability assessment with available information on current and future climate change into the DPSIR framework helps to develop adaptation responses that are relevant to other socio-economic and environmental challenges (TURNER et al., 2003; see also **Figure 2**).

The application of the DPSIR framework in the context of climate change entails analyses of the following components, which could be completed through three main steps: **Step 1** identifies the *drivers, pressures, state and trends*. It seeks to address the question of what is happening to the broader contextual factors and why changes are happening, identifying the trends associated with it; **Step 2** focuses on the *impacts* of climate variability and change and its consequences and projections for the environment and humanity; and **Step 3** investigates the *responses* and the coping and adaptive capacities in the context of these changes by questioning what is being (or can be) done and how effective it is (will be). These responses are normally measures that not only need to be taken to address the climate change impacts, but also to address the drivers and pressures on ecosystems (ERIKSEN et al., 2011). As a goal to achieve, responses or adaptation measures should be able to promote sustainable development, maximizing the welfare of human beings and guaranteeing environmental quality (UNEP, 2009). In this sense, it is important to distinguish between coping and adaptation strategies. While coping strategies may undermine capacities to respond to future threats, adaptation actions aim to create proactive responses that help build future capacities.

3 The Northern Coast of the State of São Paulo (*Litoral Norte Paulista*), Brazil

3.1 Geographic Location and Main Features

The Northern Coast of the State of São Paulo is formed by four municipalities: *Caraguatatuba; Ilhabela, São Sebastião* and *Ubatuba*. The region's landscape is marked by the *Serra do Mar*, a long system of mountain ranges and escarpments in Southeast Brazil, which runs in parallel to the Atlantic Ocean coast. The main escarpment forms the boundary between the sea-level and the inland plateau (*planalto*). In general, hill slopes are very steep, often more than 35-40º. The soil is naturally and historically susceptible to erosion and landslides making the occurrence of mass move-

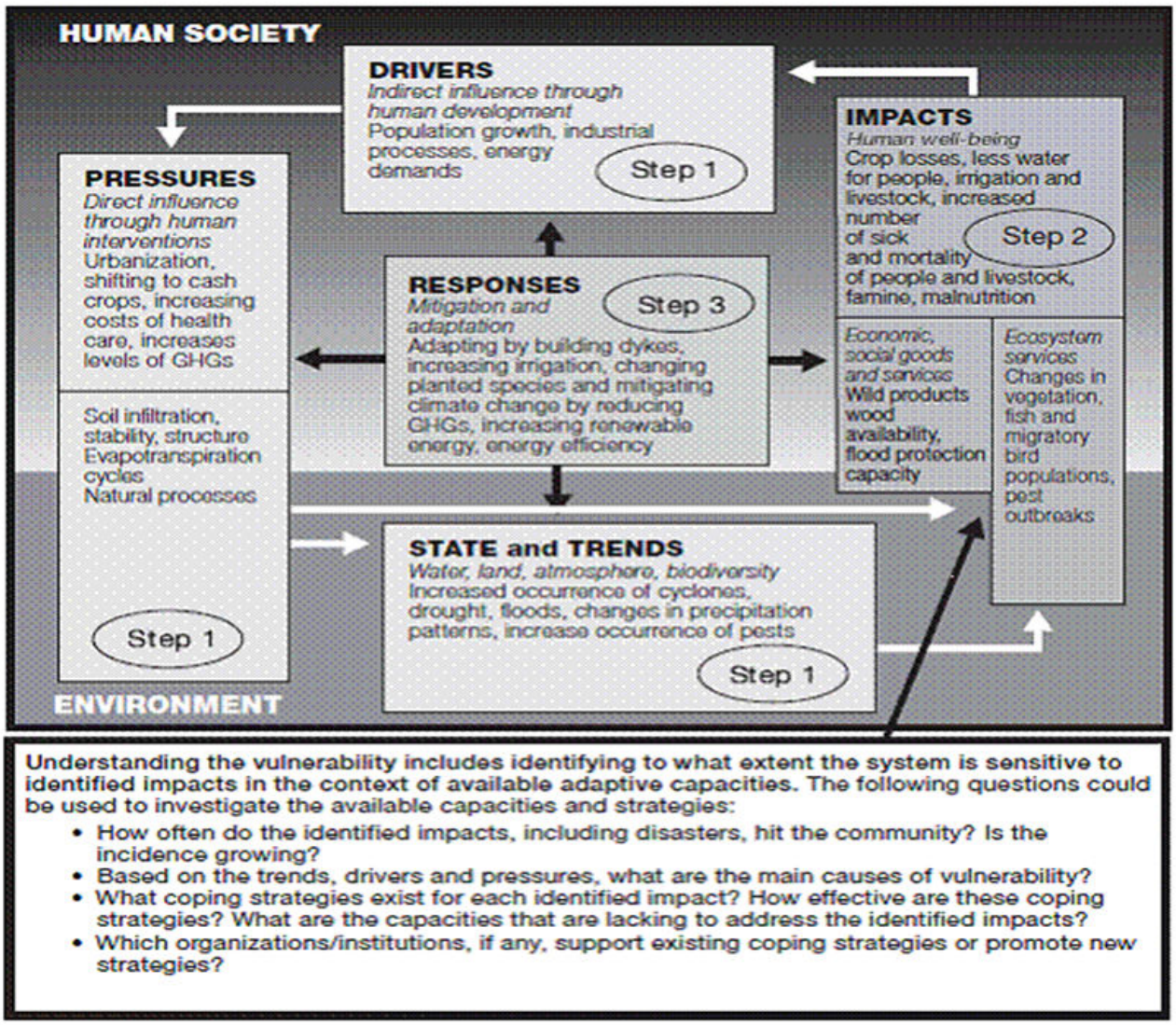


Figure 2 – Vulnerability assessment through the DPSIR framework: a step by step approach
Source: Adapted from BAAS et al. (2008)

ments common in the region (MENDONÇA, 2010; VIEIRA et al., 2010). The mountain is discontinuous in several places and also extends itself to some large islands near the coastline such as *Ilhabela* and *Ilha Anchieta* (the latter belonging to the municipality of *São Sebastião*).

The *Serra do Mar* also supports one of the richest, highly diversified, and most threatened ecosystems on the planet: the Atlantic rainforest (*Mata Atlântica*). However, the combination of intense processes of deforestation and urbanization has caused a discernible fragmentation of the native vegetation, most of them in the coastal region (METZGER, 2009; RIBEIRO et al., 2009). This area is among the top five world's biodiversity hotspots for conservation, with a high number of endemic species (MYERS et al., 2000), which has fostered its protection by different forms of national and state-level conservation units (*e.g.* parks, ecological stations) that account for more than 80% of the total territory of the Northern Coast of the State of São Paulo (see **Figure 3**). The majority of these protected areas are within the borders of the *Serra do Mar* State Park (Decreto Estadual 10.251/1977) that is administrated by a State Foundation (Fundação Florestal) and belongs to the Atlantic Forest Biosphere Reserve, considered to be of extreme biological importance (SMA, 2009).

3.2 Socio-economic Characteristics and Trends

The process of human settlement in the region dates back to the colonial period although significant economic activities have only been seen after important roads (*e.g. Rod. Oswaldo Cruz, Rod. Rio-Santos and Rod. dos Tamoios*) were built during the 1960s and the 1980s allowing the connection of the Northern Coast with important axes of transport and economic development in the State of São Paulo[3] (BORELLI, 2008). The process of urbanization began with the operation of the *São Sebastião* port in 1955. In the following years, the municipality of *São Sebastião* have also become a major Brazilian point of oil distribution and commercialization after the construction of an important marine oil terminal connected to the São Sebastião port by the Brazilian oil company *PETROBRAS* (SMA, 2009; BORELLI, 2008). The improved access to the region have also stimulated the tourism exploitation of its remarkable natural landscape made by the presence of the *Serra do Mar*, remnants of *Mata Atlântica*, several beaches, rivers, waterfalls and islands (SMA, 2009). Since the late 1970s, tourism has been considered one of the main economic activities[4], leading to an expansion of the real state market to supply the demand for beach houses (*e.g. segunda residência*). This context has set the primary conditions to foster the abovementioned process of touristic urbanization, resulting in speculation of land prices, social and environmental conflicts without appropriate control from the municipal and state authorities (BORELLI, 2008).

In the 1980s, the region was already a major destination for people from different parts of Brazil, most of them with low levels of formal education, that were looking for job opportunities in sectors such construction, building and services (*i.e.*

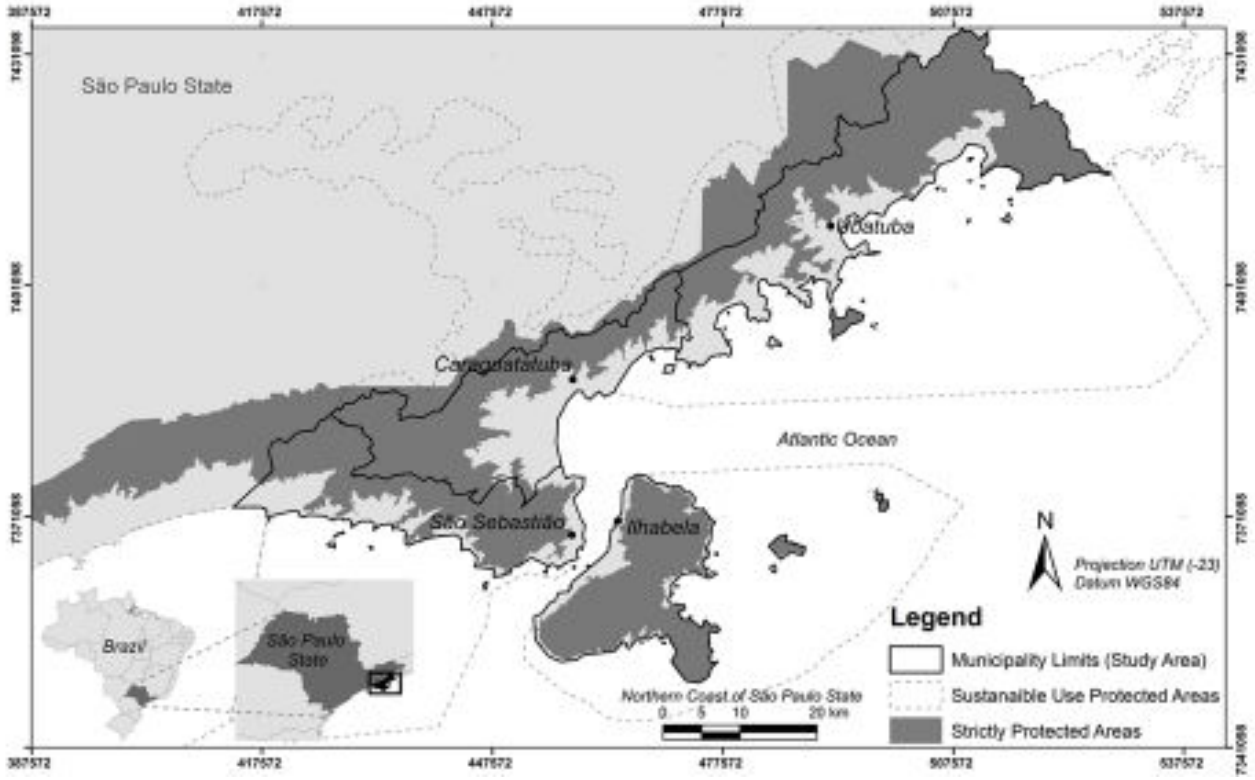


Figure 3 – Geographic location including municipal boundaries and strictly protected areas for environmental conservation on the Northern Coast of the State of São Paulo, Brazil
Source: Allan Y. I. Mello (NEPAM/UNICAMP, 2011).

gardening, private security, cleaning, *etc*). Like many other Brazilian urban areas, the result was an explosion in informal/illegal settlements including the invasion of strictly protected areas, followed by a process of disordered urban growth as one of the immediate consequence of urbanization, with the poor and traditional groups (*e.g. caiçaras*) being pushed away from coveted areas as they not only did not have the financial means to pay for the rising property/land prices. The scarcity of available land due to the presence of extensive proportion of strictly protected areas and the increasing demand for high-income residences have also contributed to this process.

As discussed by RIBEIRO (2008), the development of urban areas in Brazil deserves careful analysis and consideration. The seminal work of geographers such as Milton Santos (1994) and Ana Fani Carlos (2001), among others, has highlighted not only the pace and intensity of the urbanization process, but also land and property speculation as its main driving-forces (see RIBEIRO, 2008 for a comprehensive review in terms of urbanization and climate change). The political economy of Brazilian cities has been regarded as the transformation of large amounts of rural land into urban areas to serve the interest of the property market and real state industry without social or justice concerns (*e.g.* SINGER, 1977 *apud* RIBEIRO, 2008).

In the case of the Northern Coast of the São Paulo, the lack of adequate housing policies at the municipal and state-level and the absence of other options forced these groups – largely made of poor migrants and traditional groups – to settle in the slopes of the *Serra do Mar* even considering its illegal character and the risk of natural hazards. The illegal and informal settlements have also led to increasing levels of environmental degradation (*e.g.* water pollution and ecosystem stresses), deforestation and social conflicts between the new settlers, tourists and traditional communities, challenging the state of the environment and the regional development path (BORELLI, 2008; SMA, 2009). It is important to note that some of these traditional groups have had their livelihood based on artisanal fishing for centuries. However, the rate and state of the region's socio-environmental degradation driven by increasingly port, tourism and other human activities are forcing fishermen to change their occupation not only because fish catch are decreasing but also due to the lack of adequate policies for this population. In addition, several beaches and some rivers of the region are also presenting lower levels of water quality, undermining leisure activities and fresh-water availability (BORELLI, 2008; SMA, 2009).

More recently, important oil and gas reserves in the pre-salt layer located within the Coast of the State of São Paulo have repositioned the region to receive major infrastructure investments to allow the exploitation of these resources, paving the ground for a new cycle of urbanization and human activities (SMA, 2009). As a result of this process, major changes for the future are likely to replenish (negative) socioeconomic and environmental trends for the region (SMA, 2009). The prospect of the region not only as a major tourism destination but also as an industrial site has resulted in a number of ongoing public and private initiatives that are being planned and implemented. This includes the construction of industrial complexes, pipelines facilities, offshore platforms and a permanent gas treatment plant in the municipality of *Caraguatatuba* under responsibility of *PETROBRAS*. In addition the São Sebastião port is being enlarged to become one of the leading import/export operators in Brazil (see SMA, 2009 for a summary of the investments).

There are also various other projects being coordinated, mainly by the state government in partnership with the national government and private investors, seeking to expand the logistic capacity and accessibility of the region through better transport/highway facilities. The improvement of public infrastructure is also considered in perspective to prepare the region for the estimated increase in economic activities. These foremost investments are likely to alter even more the socio-economic dynamic and the regional landscape although it is too early to assess major changes besides those that have been already taking place in the last decades.

These recent developments not only underline the main pressures for the regional future, but also shed some light on the transformations that have been and are likely to continue to influence the four municipalities of the Northern Coast in terms of its urbanization process. A glimpse of these transformations becomes apparent by the scale of the population growth, not only in the last four decades (BORELLI, 2008) but also for the coming years (see SMA, 2009 for estimates). In order to illustrate this situation, the population of the region has risen from about 24,300 in 1950 to approximately 280,000 in 2010 (see **Table** and **Graph 1**). Although the pace of population growth has been slowing down in the last decade (see **Table** and **Graph 2**), the municipalities of the region are still ranked among the highest population growth rates in the State of São Paulo. SMA (2009, p. 145) provided population growth projections for the Northern Coast based on three scenarios that encompassed different trends in new investments and infra-structure development. According to these simulations, total population in four municipalities by could range between 355,000 (inertial growth scenario) and 406,000 inhabitants (extreme expansion scenario) by 2025 (see **Table 3**).

Besides the population dynamic discussed above, another aspect that deserves attention is the temporary or additional population as a result of the tourism activities during the high season (*e.g.* New Year, carnival, summer/holidays). According to informal estimates provided by the municipal administrations, the population during these periods can easily rise above one million people. This reality brings many challenges for providing basic services as the regional infrastructure is already poor.

3.3 Projected Impacts of Climate Variability and Change

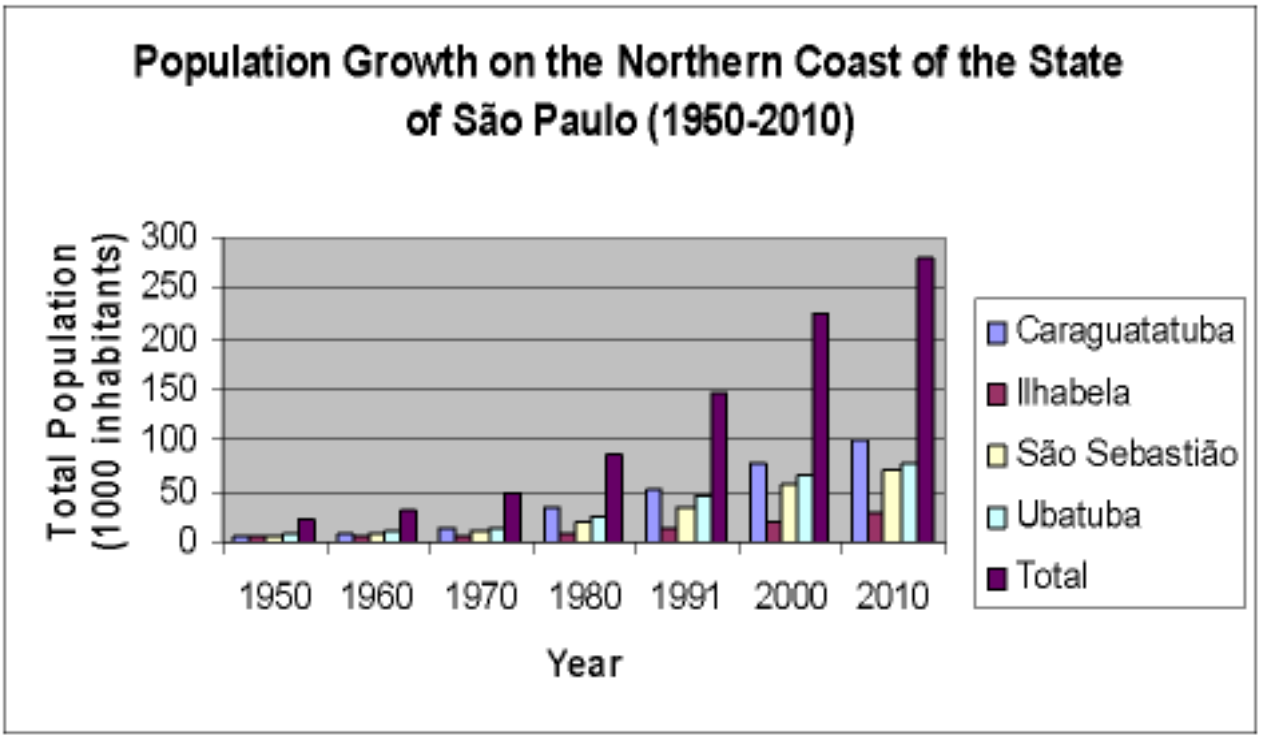
Despite specific critiques, the IPCC Fourth Assessment Report left little room to question global temperature increases by providing new and sound evidence of the discernible influence of human activities on the Earth's climate since the pre-industrial time. Global warming is contribu-

Table 1 – Population Growth on the Northern Coast of the State of São Paulo (1950-2010)

Municipalities	Total Populations (approximately)						
	1950	1960	1970	1980	1991	2000	2010
Caraguatatuba	5,400	9,800	15,100	33,800	52,900	79,000	100,900
Ilhabela	5,000	5,100	5,800	7,800	13,600	20,900	28,200
São Sebastião	6,000	7,400	12,300	19,000	33,900	58,100	73,200
Ubatuba	7,900	10,200	15,400	27,000	47,400	66,800	78,900
Total	**24,300**	**32,500**	**48,600**	**87,600**	**147,800**	**224,800**	**281,200**

Source: IBGE.

Graph 1 - Population Growth on the Northern Coast of the State of São Paulo (1950-2010)



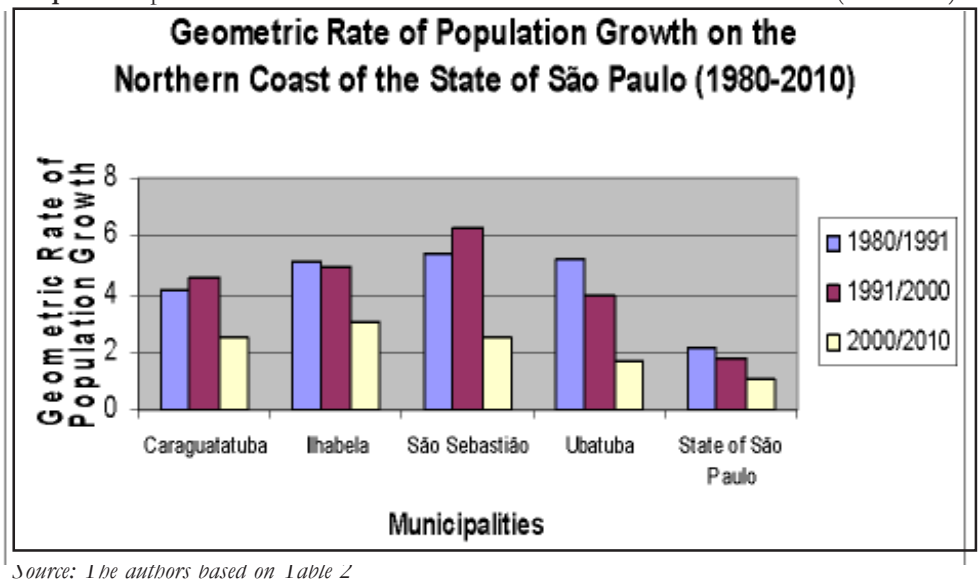
Source: The authors based on Table 1

Table 2 – Geometric Rate of Population Growth on the Northern Coast of the State of São Paulo (1980-2010)

Geometric Rate of Annual Population Growth (% per year)			
Municipalities	**1980/1991**	**1991/2000**	**2000/2010**
Caraguatatuba	4,17	4,56	2,50
Ilhabela	5,13	4,95	3,09
São Sebastião	5,35	6,26	2,48
Ubatuba	5,18	3,97	1,68
State of São Paulo	2,12	1,82	1,09

Source: SEADE.

Graph 2 - Population Growth on the Northern Coast of the State of São Paulo (1950-2010)



Source: The authors based on Table 2

Table 3 – Projections for Population Growth by 2025 based on Three Different Development Scenarios.

Municipalities	Scenarios		
	Little expansion with only inertial growth	Moderate expansion including new infra-structure facilities	Intensive expansion including new infra-structure facilities and pre-salt investments
Caraguatatuba	108,767	116,809	144,274
Ilhabela	40,412	41,101	43,455
São Sebastião	93,578	94,956	99,665
Ubatuba	112,937	114,316	119,024
Total	**355,693**	**367,182**	**406,417**

Source: SMA (2009, p. 145).

ting to glaciers and permafrost melting, particularly in the Arctic region. It is increasing not only the temperature of the oceans, but also the mean sea-level (IPCC, 2007). In terms of climate change on the Brazilian coast, there are only few assessments available to date that project future impacts for particular regions of the country (NEVES & MUEHE, 2008). On the Coast of the State of São Paulo the situation is even worse, with only very few studies considering these impacts so far (*i.e.* SOUZA, 2010). On the other hand, the scientific community dedicated to modeling and predicting the climate has started to collaborate with social scientists in order to provide robust analysis that can contribute for planning the future. In this context, studies on climate change impacts for the State of São Paulo and the Brazilian Southeast region are emerging, mostly based on the downscaling of global circulation models (GCM) that are regularly used to project climatic changes by 2100 (*i.e.* MARENGO et al., 2007; MARGULIS et al., 2010).

In general, these studies point to increases in average, minimum and maximum **temperatures** in Brazil; those temperatures are likely to rise over the coming decades as a clear consequence of global warming (see **Figure 4**). In the State of São Paulo, the number of warm days and nights, which were about 5% in 1950, reached 35% in the beginning of the twenty-first century. On the other hand, the frequency of cold days decreased from 25-30% in 1970 to 5-10% in the same period[5] (SOUZA, 2010). Despite the great uncertainties that surround these predictions at the regional and local scales (see WIGLEY, 2009 for a discussion), MARENGO (2007) projects an increase between 2ºC and 3ºC in average temperature for the Brazilian Southeast region by 2100. These studies corroborate with the widespread global and South American climate change projections presented by IPCC (2007), that predict an increase in average temperatures for South America (MARENGO, 2007; MARENGO et al., 2007).

Regarding **precipitation** and **rainfall** trends, studies seem to note the incidence of interdecadal variations not only in the State of São Paulo, but also in other Brazilian regions (SOUZA, 2010). Observed evidence in the last 40 years suggests a slightly increase in rainfall patterns in South and Southeast regions, mainly due to the influence of the South Atlantic Converge Zone (SACZ) that is regulated by temperature anomalies in the South Atlantic ocean, providing the conditions for more intense, frequent and concentrated rainfalls in the Southeast region (SOUZA, 2010). Projections in terms of precipitation varies widely even within the same region, adding to the complexities and uncertainties already discussed.

Another issue that has been mobilizing intense academic debate in the last few years is the possibility that global warming may influence the magnitude, frequency and intensity of **extremes**

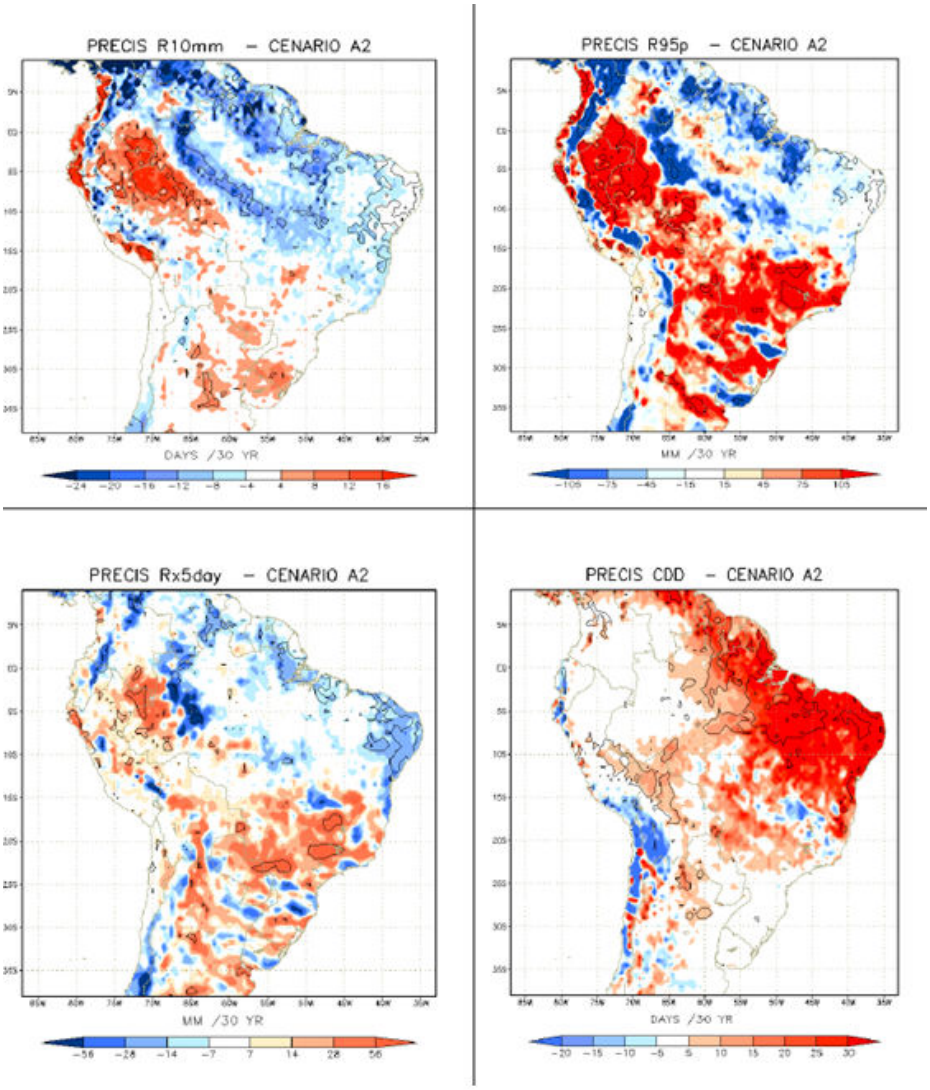


Figure 4 – Projected temperature changes for the period 2061-2100 (in relation to 1961-1990) based on A2 scenario derived from Eta/CPTEC, RegCM3 and HadRM3P
Source: Adapted from CPTEC/INPE (2007)

weather events (*e.g.* drought, storms and heat waves). Extreme weather events can be defined as climate anomalies that occur in time scales that can vary from days up to millennia, being considered rare events that are very difficult to predict in long-term time scales (MARENGO et al., 2007; WIGLEY, 2009; MENDONÇA, 2010). The uncertainties around the detection and attribution of global warming signals in extreme events are even greater than the case of average temperatures as climate models offer higher confidence for temperature predictions (WIGLEY, 2009). Not without reason, these weather events have been considered a major issue of concern by climate scientists as these events can not only lead to natural disasters, but are indeed one of the primary sources of climate-related harm, losses and deaths not only in Brazil but also elsewhere (MARENGO, 2007; WIGLEY, 2009). Recent projections undertaken by MARENGO and colleagues have indicated, notwithstanding the great uncertainties already discussed, a possible increase in the frequency and intensity of these rare short-term events, particularly those related to extre-

me hydro-meteorological phenomena (MARENGO et al., 2007; see **Figure 5**). Although there are only few studies available that highlight a possible increase in the frequency and magnitude of extremes events for the State of São Paulo (*i.e.* SALATI et al., 2007), their consequences on the Northern coast are often materialized in the form of losses and casualties not only due to the frequent landslides that take place in the slopes of the *Serra do Mar*, but also the floods observed in low elevation coastal zones (FURIAN et al., 1999). It is also important to highlight that global climate change often juxtaposes the region's susceptibility to natural climate variability, being difficult to detect and attribute the influence of global trends in the local climate (WIGLEY, 2009; MENDONÇA, 2010).

SLR and its consequences for LECZ are also a foremost issue of interest and concern for the scientific and policy communities. Although disagreements persist, studies at the global scale predict SLR as one of the most certain impacts of global warming (CROSSLAND et al., 2005; NICHOLLS et al., 2007; KRON, 2008). In Brazil, recent research showed that the sea level is rising along its coast (*i.e.* MESQUITA, 2004; NEVES MUEHE, 2008). Despite the fact that coastal monitoring has been generally poor and that the

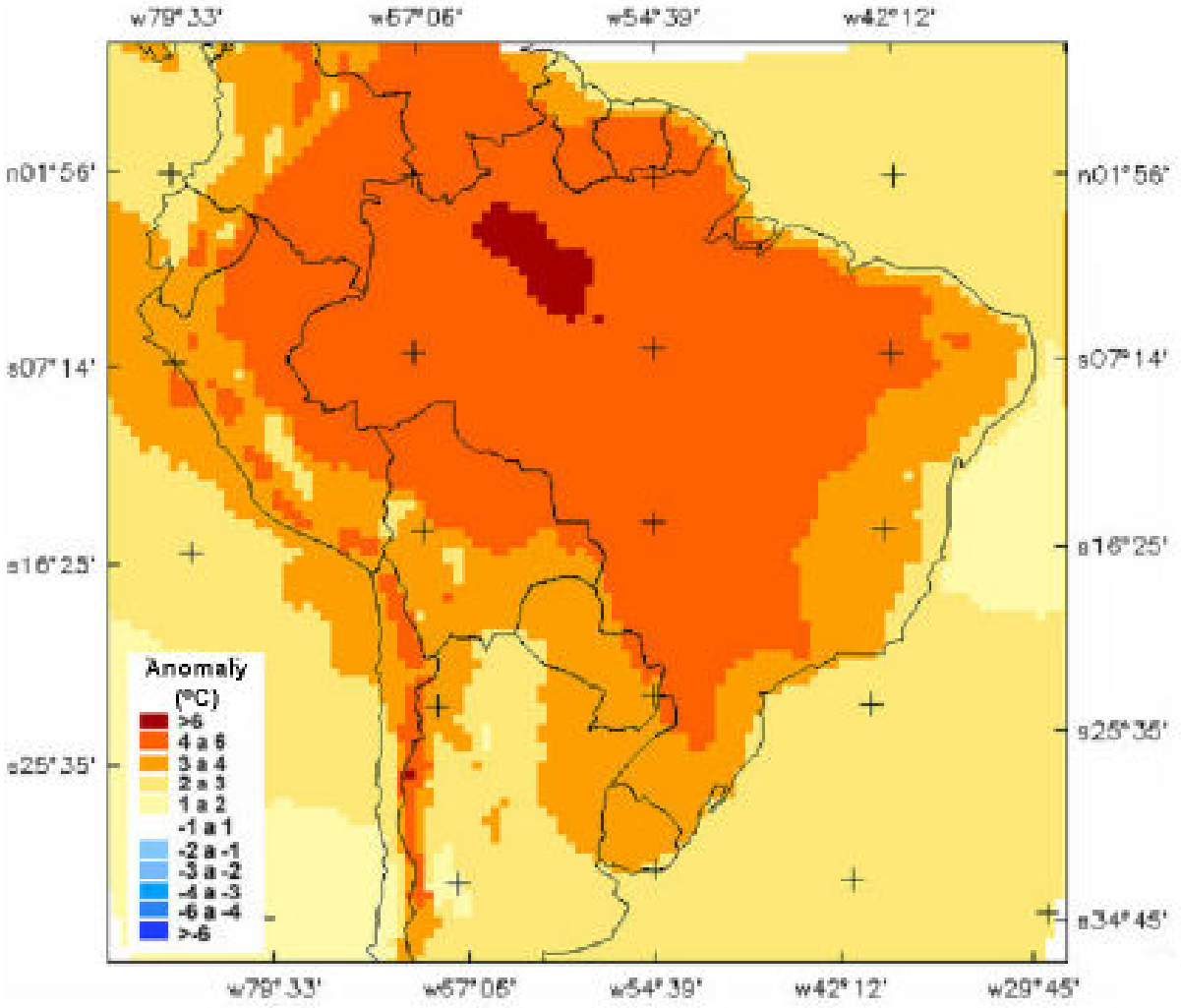


Figure 5 – Projected trends of days with rainfall of more than 10 mm R10, days with rainfall above the 95 percentile R95P, and events of intense rainfall for 5 consecutive days RX95P using the HadRM3 regional model, A2 scenario, for the period 2071-2100
Source: MARENGO et al. (2007)

country lacks comprehensive and accurate time series and datasets for these analyses (see NEVES & MUEHE, 2008 for a comprehensive discussion and critique), MESQUITA (2004) has suggests that sea-level has been rising on the Coast of São Paulo. Based on long-term measures available for specific sites, this author provided SLR estimations of around 40 cm in the last 100 years (most of it the last 50 years). SLR is not only expected to flood LECZ, but also to influence the intensity and magnitude of **coastal erosion** and **storm surges** (NICHOLLS et al., 2007).

The changes in temperature, rainfall patterns and mean sea-level combined with several other effects and feedbacks of global warming (*i.e.* acidification of the oceans) can bring severe consequences for the environment and human populations (IPCC, 2007). In the coastal zone of the State of São Paulo, climate change is expected to negatively impact coral reefs, mangroves, and other marine ecosystems that are common to its Northern Coast, particularly Ubatuba. Climate change may alter physiology, metabolism and behavior of a variety of organism, influencing their growth, reproduction, survival and geographic distribution with real possibilities of introduction and extinction of species (SOUZA, 2010). In terms of the ecosystems found in the Atlantic forest (*Serra do Mar*), the combination of increasing levels of CO_2 and higher air temperatures is also expected to alter the physiology, growth and metabolism of plants and animals with likelihood of both positive and negative outcomes and feedbacks that will vary according to different species and certain thresholds (MEA, 2005; METZGER, 2009; SOUZA, 2010).

In terms of the human dimensions of climate change, the intensification of the hydrological cycle and SLR may increase the incidence and magnitude of natural hazards that are already common to the region, particularly coastal erosion, storm surges, floods, and landslides (SOUZA, 2009; 2010). SOUZA (2010) argues that evidence observed suggests that the number and intensity of storm surges affecting beaches of the State of São Paulo have been increasing in the last decade. Indeed, different locations of its coastline (> 50% of the beaches) have already been flooded or are suffering from high levels of coastal erosion, including several beaches on its Northern Coast (SOUZA, 2003; 2009; 2010). Information provided by the Civil Defense bodies in the region reports that more than 50% of the incidents between 2000 and 2008 were related to flash-floods and floods; 19% of them were landslides and mass movements with increasingly number of people being affected by both hazards. Although it is not possible to assert that these events were caused or influenced by global warming due to the lack of scientific knowledge and basis, they provide a snapshot of what may or will happen in the future.

Higher temperatures and changes in rainfall patterns will also positively influence the reproduction of insects that are found in marine, urban and forestry ecosystems. Some of these insects are transmitters of vector-borne diseases such as dengue, malaria, yellow and typhoid fever (SEIXAS et al., 2009; SOUZA, 2010). A number of fungus, microbes, germs and bacteria that can spread allergies and infectious diseases can be also be found in the region and are very sensitive to temperature and rainfall variation increasing the risks of epidemics. BORELLI (2008) reported official data showing the incidence of some of these diseases, including those related to poor air and water qualities, well above the average observed for the rest of the State of São Paulo. SEIXAS et al. (2009) have analyzed the implications of climate change for health in the municipality

of *Caraguatatuba*. Their study shows a striking number of dengue illnesses as well as the presence of the mosquito *Anopheles darlingi* responsible for spreading malaria. In addition, there have been cases of cholera, cutaneous leishmaniasis, and respiratory diseases reported in the last decade. Based on official data, these studies not only raise several reasons for concern but also provide a glance of how the consequences of a changing climate are likely to impact the region in terms of health issues.

Another reason for concern is SLR and coastal erosion. Although generally long-term natural processes, intensive human activities combined with changes in the global climate system are likely to amplify both phenomena (SOUZA, 2003; 2009; 2010; NICHOLLS et al., 2007; NEVES & MUEHE, 2008; ZAMBONI & NICOLODI, 2008). Coastal erosion and coastline alterations due to SLR can also severely impact port activities, private residences, urban drainage and sewage/sanitation systems with negative and largely unknown consequences for the Northern Coast. SLR may also bring salinization and great increase of phytoplankton in water bodies with financial and material losses and harmful effects for the environment such as depletion of Oxygen levels and reduction of fish and other marine animal populations (eutrophication) (NEVES & MUEHE, 2008; SOUZA, 2010).

4 Unpacking the Governance Challenge: Existing Vulnerabilities and Limited Adaptive Capacity to Address Climate Risks

4.1 Characterizing the vulnerability to climate variability and change

Among the social groups that are more exposed to climate variability, change and extremes, SLR and future climatic changes are thousands of low-income families residing in informal and illegal settlements in the four municipalities of the Northern Coast. It is also important to note that there are some and some middle- and high-income households located mainly in *Ilhabela* and *Ubatuba* that occupy risk-prone areas. The low-income groups are composed by artisanal fishermen and people without professional qualification that work in the construction sector or doing cleaning and housekeeping for the second residence houses. In general, these families possess small capital assets, low and irregular income and little formal education, living in informal settlements exposed to climatic events (BORELLI, 2008; SMA, 2009; MELLO et al., 2010).

The middle- and high-income groups are mainly characterized by people that live in bigger urban centers (*i.e. São Paulo metropolitan area, Campinas, etc*) and make use of private or rented residences during the weekends, holidays or the summer season. They can also be permanent residents such as liberal professionals, retired people or specialized/educated contract workers that are living in the municipalities due to the port facilities and the emerging oil and gas industry that are offering qualified jobs. These people enjoy the availability of bigger capital assets and live in solid house structures which are located in places that are in general less vulnerable to flooding or landslides. Although there is the presence of high-income households in risk-prone areas, most losses and casualties that have been reported so far are mostly concentrated within those that belong to the low-income groups.

Previous analyses that consider the exposure of the regional population to climate change impacts have shown that the vulnerability of so-

cial groups vary disproportionately among them (MELLO et al., 2010). Using data from the 2000 Census, MELLO and colleagues considered that the areas most vulnerable to climate change impacts are those located either in less than 500 m from the coastline (susceptibility to being flooded by SLR) or in the *Serra do Mar* slopes that are higher than 30º (susceptibility to instabilities such as mass movements and landslides triggered by intense rainfalls and precipitation events). In terms of social vulnerability, the study adopted the figures from the State of São Paulo Vulnerability Index (*Índice Paulista de Vulnerabilidade Social* – IPVS) (MELLO et al., 2010). According to the applied methodology, more than 30% of the urban population (98% of the total population) of the Northern Coast was estimated as being high or very high vulnerable to climate change impacts combining high or very high social vulnerability and exposure to landslides by living in steep slopes. In addition, around 28% of the population was considered exposed to SLR residing in less than 500m from the coastline[6].

Another issue that deserves detailed consideration is the socio-economic status of the region that broadly determines its sensitivity to climate impacts. Although the State of São Paulo and many of its municipalities rank among the highest socio-economic indicators in Brazil, the four municipalities of the Northern coast are below the state's average in a number of these indicators such as death rates, per capita income, GDP per capita, and illiteracy among others (see **Table 4**).[7]

Despite the presence of groups that could be considered of high and very high social vulnerability, the way that the region has developed – fast and without plan and control – has also brought serious environmental challenges. Official data for the four municipalities of the Northern Coast shows that the freshwater supply system is satisfactory with high levels of water availability in the watershed due to the abundance in precipitation levels, there are problems in *Ilhabela* and *Ubatuba* where only 70% and 77% of households have access to freshwater through the SABESP system. The same is valid for the solid waste collection, with around 85% of the residences are contemplated by this service. On the contrary, the figures for sewage collection and treatment are as disturbing as in other Brazilian regions where only a minority of the regional population has access to this service. On the Northern Coast, these numbers vary widely between the municipalities (see **Table 5**).

The limited access to sewage collection and treatment in the region is not in compliance with the National Sanitation Act (Law 11.445/2007). The illegal disposal of sewage is causing soil and water pollution, with serious social and environmental consequences. The lack of adequate sanitation system is also discernible through the decline in seawater, beaches and rivers general environmental quality as annually reported by the State of São Paulo Environmental Agency (CETESB). Although major investments are underway to reduce the deficits in environmental sanitation, the extent of the population growth and the agglomeration of tourists and residents during particular periods of the year challenge the sustainability of current and future activities in the region as disruptions in these services are already noticeable (BORELLI, 2008). Considering the magnitude and nature of the ongoing and expected developments associated with port activities and oil and gas industry, these investments are not only insufficient but also yet to consider climate change in its plans. On the other hand, some studies are starting to raise concerns that SLR will have important effects on sanitation systems along the Brazilian coastline

Table 4 – Indicators of Health and Life Conditions on the Northern Coast of the State of São Paulo

	Year of Data	Caraguatatuba	Ilhabela	São Sebastião	Ubatuba	State of São Paulo
Health						
Birth rate (per 1000 inhabitants)	2007	15,44	17,94	18,1	15,16	14,65
Child mortality (per 1000 births)	2008	12,89	15,78	15,2	11,22	12,56
Infancy mortality (per 1000 births)	2007	21,04	19,23	11,33	19,69	15,2
Adolescent mothers (less than 18 years old)	2007	8,06	6,84	7,44	9,19	7,31
Life Conditions						
Municipal HDI	2000	0,802	0,781	0,798	0,795	0,814
Per capita income (in minimum wages)	2000	2,16	2,24	2,38	2,1	2,92
Households with per capital income less than ¼ of minimum wage	2000	7,57	4,99	5,25	7,18	5,16
Households with per capital income less than ½ of minimum wage	2000	14,13	13,24	11,7	15,74	11,19
Education						
Illiteracy rate (%)	2000	8,02	9,31	8,84	8,77	6,64
Average years of education (in population between 15 and 64 years old)	2000	6,96	6,49	6,69	6,71	7,64
Population over 25 years old with less than 8 years of education (%)	2000	61,03	64,95	63,12	62,93	55,55
Population between 18 and 24 years with secondary school diploma (%)	2000	33,16	26,3	25,08	29,41	41,88

Source: SEADE (2009)

and there is widespread lack of awareness to this and other climate change issues in Brazil's coastal zones (NEVES & MUEHE, 2008; TCU, 2009; SOUZA, 2010).

Sensitivity to climate change is also highly dependent on the level of household assets (PELLING, 2003; UNEP, 2009). On the Northern Coast, it is possible to notice that the majority of people responsible for permanent private households are in the range between 1 and 5 minimum wages (73,6%); 38,1% earns no more than 2 minimum wages and 35,5% are between 2 and 5 minimum wages. At the same time, people in the range between 5 and 10 and more than 10 minimum wages are the minority with 16,9% and 9,5% respectively.

Table 5 – Sewage collection on the Northern Coast of the State of São Paulo (2007)

System status	Caraguatatuba		Ilhabela		Ubatuba		São Sebastião	
	Population	%	Population	%	Population	%	Population	%
In operation	38,208	45	878	4	15,527	24	20,020	30
Available but not in operation	10,932	13	*n/a*	*n/a*	19,497	30	7,024	11
Under construction	14,628	17	5,868	26	*n/a*	*n/a*	5,170	8
Planned	13,084	15	6,948	30	7,384	32	1,129	2
Private	477	1	*n/a*	*n/a*	1,439	2	2,075	3
Not projected	7,275	9	9,128	40	20,679	32	30,946	47
Total	**84,604**	**100**	**22,822**	**100**	**64,526**	**100**	**66,364**	**100**

Source: Adapted from SMA (2009).
(n/a) indicates that the data is not available.

4.2 Adaptation and the capacity to address climate variability and change

The capacity of many municipal administrations in Brazil, particularly the small cities (less than 100,000 inhabitants), to address climate risks is generally weak (MARTINS & FERREIRA, 2011a; 2011b; FERREIRA et al., 2011). However, the four cities that compound the Northern coast of the State of São Paulo have been collaborating with state-level authorities to implement some adaptation strategies in order to minimize the adverse effects of climate variability and change on the coastal communities. These include raising the awareness of those who live in highly vulnerable areas, providing relief assistance and evacuation of homes when there are forecasts for heavy rainfalls. These measures are part of the Civil Defense Preventive Plan (*Plano Preventivo de Defesa Civil* – PPDC) that involves municipal and state-level Civil Defense bodies. In general, it seeks to provide instruments and strategies to reduce the number of losses and casualties resulting from floods and landslides in the *Serra do Mar* region particularly during the rainy season (November-March).

Although the plan have been in place for the last two decades now, with important outcomes in terms of reduction in the number of casualties and considerable improvements in terms of its functioning and methodology, the plan was not combined to structural reforms in terms of addressing the root causes of vulnerability, namely the lack of land regularization and access to safe and affordable houses for the low-income families. The historic omission and neglect of different public authorities that juxtaposed the socio-economic dynamics already discussed above have contributed to deepen the problem with an increasingly number of families settling in high-risk areas over the years despite the Civil Defense efforts to reduce the risk of natural disasters.

With a situation that was clearly going out of control, the resettlement of some families to safer areas became the focus of a specific programs after decades of political inaction in the region. Following a partnership with the Inter-American Development Bank (IADB), the government of the State of São Paulo has recently initiated a large-scale program to reinforce the conservation of the *Serra do Mar*. This initiative involves several municipalities, including those of the Northern coast, and seeks to remove illegal settlements within various strictly protected areas of the *Serra do Mar* State Park. The program has as the prima-

ry focus the idea to resettle the families into safer and newly built locations, with the majority of them living in the "quota neighborhoods" (*Bairros Cota*) in Cubatão[8]. Although this initiative is not specifically targeting neither climatic impacts nor its change or variability, it also has the potential to alleviate the exposure of some vulnerable families residing within the limits of the *Serra do Mar* Park, including on the Northern Coast. Other families are living in risk-prone areas, but will not benefit from the resettlement and conservation program as they are not living within the limits of the *Serra do Mar* State Park. In this case, the responsibility for promoting specific policies rests with the municipal governments that have been historically failing to address the root causes of vulnerability and risk in the region.

In this sense, the capacity to implement the required policies and more specifically climate change adaptation, that is also termed its adaptive capacity, is determined by the broader socio-economic and the political context of the regional and municipalities, with a number of different contextual and institutional factors related to past and ongoing processes influencing the adaptive capacity of the four cities to undertake these adaptive strategies. Usually, adaptive capacity is not only related to the resources available, but also political and institutional support (PELLING, 2003; TURNER et al., 2003; SMIT & WANDEL, 2006). Adaptive capacity is thus fundamentally dependent upon the governance landscape of those who must adapt and the characteristics of a particular place (REVI, 2008; SATTERTHWAITE, 2009).

Adaptation can also make use of changes in institutions and management strategies (REVI, 2008; MARTINS & FERREIRA, 2011a; 2011b). Municipal governments in Brazil have a number of competences and jurisdiction to implement local adaptive strategies such as to limit the urban development in highly exposed areas, to alter the land use ordinance and building code, and implement coastal zoning[9], among other responsibilities that are part of the framework introduced by the 1988 Federal Constitution and regulated by the 2001 Statute of the City (MARTINS & FERREIRA, 2011b; BUENO, 2011; FERREIRA et al., 2011). In this context, one of the most important instruments that could be mobilized to respond effectively to the regional problems at the local level is the Municipal Masterplans (*Plano Diretor* – PD)[10] (FERNANDES, 2007a; BUENO, 2011). According to the 2001 Statute of the City, municipalities with more than 20,000 inhabitants had to develop municipal masterplans with citizen participation until October 2006. Municipal masterplans seek to set the basis for strategic development and urban planning, providing guidelines and regulation for land use, zoning and public budget priorities in a way to promote social justice and urban infrastructure through access to public services and social policies, including housing (FERNANDES, 2007a; 2007b; BUENO, 2011).

Among the municipalities of the Northern coast, only *Ilhabela* and *Ubatuba* have developed, revised and approved their masterplans complying with the institutional framework provided by 2001 Statute of City. *Caraguatatuba* and *São Sebastião* did not meet the 2006 deadline and are still in the process of discussion and approval of the plans with fierce debates taking place in the Local Councils, possibly due to the various economic and political interests that exist in both cities. The main point of controversy is related to proposals that seek to liberate the construction of tall buildings in order to provide housing alternatives for the increasing population in both cities. Some argue that it will undermine the tourism character of the region, compromising its impressive natural

landscape. Others see this as the only solution for the situation of lack of housing and trends for growing population due to port, oil and gas activities. On the other hand, although these plans have the potential to set the basis for a sustainable future, without strong political commitment and law enforcement, the problems arising from rapid urbanization and lack of urban planning in both cities will continue to deteriorate as most vulnerable families are not expected to benefit from the changes in regulation as their family income will not allow them to purchase the new housing supply. In this sense, it is also necessary to combine strong social policies with progressive urban planning that not only require profound commitments that go well beyond the changes in legislation, but also support from higher levels of governance (state- and national-level). As GOULART (2008) argues, institutions are important but politics make the difference in the approval and outcomes of municipal masterplans. The discontinuity in local politics combined with powerful private interests has been undermining these processes and the possibility for clear guidelines that could change the situation in both cities.

This discussion is illustrated by the municipal governments estimating that 10,000 families are living in illegal/informal and risk-prone areas; half of these families will not directly benefit from the *Serra do Mar* program. It means that the four cities will have to provide adequate housing for these social groups. Although the analysis of the cities show that they are equipped in terms of secretariats, departments, directories and other types of administrative to deal with urban planning, and social and environmental policies, the lack of resources and personnel is a reality on the Northern Coast (see FERREIRA et al., 2011 for details on the municipal capacity of the Coast of the State of São Paulo). Although institutional capacity is important, different aspects need to be mobilized to address and advance climate change issues as well as to plan for climate change adaptation. Despite the presence of institutions and administrative bodies in the four cities, the existing political structures are weak and the alternatives that have been proposed so far were not able to support technical, social and political advances neither in terms of social inclusion nor in terms of climate change responses.

On the contrary, it has been considered as being far from sufficient to respond effectively to the magnitude and complexity of the climate change challenge in the region (FERREIRA et al., 2011). As decisions (or the lack of them) taken by different actors and levels of governance have been determining the future of the region for the last four decades, there are reasonable arguments to defend deeper social engagement in collective and political dialogues, negotiation and proposals that could not only enhance the responses but also the adaptive capacity of the municipalities to address the challenges arising from both climate variability and change and unsustainability. It is essential to get away from the traditional measures deployed by Brazilian local and subnational governments that have been largely palliative. In this sense, the analyses considered in this paper points to the direction that climate change adaptation that are effective in reducing the vulnerability of those at risk will need a stronger policy and institutional framework in order to deliver better responses that have to go beyond reformist views that do not address the root causes of vulnerability to climate variability and change, that goes beyond the exposure to climatic hazards, and are largely shaped and determined by the way Brazilian cities have been growing, in other words as sites of social injustice, private interests and unsustainable patterns of economic development.

Table 6 – Possible adaptive strategies for the municipalities located on the Northern Coast of the State of São Paulo

Response options	Possible measures
Retreat (progressive abandonment of high risk and vulnerable areas**)**	No development in vulnerable areas;
	Resettlement of households in vulnerable areas to safer zones;
Accommodation (sustainable use of the environment and continued occupancy and use of the vulnerable area through adaptive management**)**	Modification of land use ordinance and building code, enforcing the strict implementation of this ordinance/code;
	(Partial) coastal zoning;
	(Partial) protection of threatened ecosystems;
	Regulation of ecological risk zones;
Protection (defense of vulnerable areas, population centers, economic activities and natural resources)	Improvement/construction of existing roads, drainage and water systems;
	Construction of seawalls and revetments and rehabilitation of existing breakwaters/rockwalls;
	Installation of saltwater intrusion barriers and water desalination facilities;
	Restoration of coastal habitats;
	Reforestation of upland areas;
Other proposed adaptive strategies	Implementation of disaster risk reduction;
	Implementation of information campaigns to raise the community awareness;
	Strengthening municipal civil defense coordination;
	Provision of adequate technical, training, financial and organizational resources and facilities;
	Establishment of better and community-based early warning systems;
	Provision of secure housing tenure to poor families and informal settlers;
	Regular monitoring of protected areas and environment indicators.

Source: The authors based on literature review and interviews with local government representatives from the Northern coast of the State of São Paulo.

In this sense, adaptation to climate change may not be treated as only the formulation and implementation of diverse and fragmented public policies but as social and political processes that are able to advance sustainable development by addressing the root causes of vulnerability combining different technical and political strategies. Without altering the drivers of increasing vulnerability and risk at different spatial and temporal scales, policy instruments and decisions will have limited successes on adapting Brazilian cities. Particularly on the Northern Coast of São Paulo, a number o measures should be implemented, or even enhanced, as a first step to prepare these cities for a warmer and uncertain climate. Building upon discussions with policymakers and literature review (MARTINS & FERREIRA, 2011a; 2011b), the **Table 6** shows a list of possible local adaptive strategies that could be implemented by the local governments on the Northern coast of the State of São Paulo. Although the list is not exhaustive, it sheds light on practical and feasible measures that could be combined with broader and more transformative reforms aimed to reduce the pressures and reverse the trajectories of unsustainability and risk of the region.

5 Conclusion

This study illustrates the broader landscape of socio-economic transformations and the path dependency to former political and policy decisions that have been determining the vulnerability of a particular region, namely the Northern Coast of the State of São Paulo, in terms of its degree of vulnerability (exposure and sensitivity) and capacity to address the effects of climate variability and change. The socio-economic change that has driven the rapid process of urbanization, population growth and the economic activities (*e.g.* tourism, port activities and oil and gas industry) needs to be understood in terms of both local and regional contexts and the capacities available and needed for planned adaptation.

Building on an assessment of the region, the paper shows that climate variability and change is expected to continuously impact the area that is already facing different pressures and levels of vulnerability to both socio-economic and environmental change. On the other hand, earlier developments of the region have been limiting the present scope for adaptation by undermining the social-environmental conditions over the years. The exponential population growth combined with poor basic infrastructures have created a situation where the most vulnerable social groups are living in high risk areas susceptible to landslides, floods and poor quality of life at the same time that they drive environmental degradation in strictly protected areas. In additional, the lack of municipal control, law enforcement and adequate urban planning and resources has led to a condition of rising exposure and sensitivity to climate and environmental hazards such as SLR, coastal erosion, vector borne diseases and landslides triggered by heavy rainfalls that are common features in this area. Without major changes in the current situation, global climate change combined with natural climate variability is expected to worsen the situation accordingly to preliminary assessments available so far.

Conflicting interests at the municipal level in terms of poor development strategies, environmental protection and urban planning have been limiting the adaptive capacity of the region's municipalities to respond effectively to climate change challenge. There is an urgent need to improve and build the capacity of the municipal governments of the four cities that can not only support the formulation and implementation of appropriate adaptation and risk management strategies, but also reverse the path dependency of unsustainability and social exclusion. In this sense, there is not only the need for sound science-policy interaction, data and analyses, but also political will and financial and technical resources that are not available for the local governments at the moment. The possible adaptation strategies discussed in this paper will only be only feasible with strong support and commitment from higher levels of governance (state and national). The existing institutional framework available at the local level in this region does not address either climate change or adaptation specifically, but combined with stronger political commitment, they provide interesting opportunities for a first step in reducing vulnerability and enhancing the adaptive capacity through better urban planning and sustainable development pathways.

The major socio-economic changes show the importance of viewing climate change in the context of multiple stressors and other ongoing development and demographic trends. Climate variability and change represents an additional stressor to already vulnerable communities exposed to different risks, including natural hazards. The paper indicates not only the presence of di-

fferent degrees of vulnerability, but also particular aspects of the situation where vulnerability reduction strategies could be directed toward the disadvantaged social groups, bringing to light the relative importance of such issues for policy making in regards to climate change.

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Endnotes

[1] It corresponds to 39 millions people living on the coastal areas. Brazil's total population is estimated of being around 193 millions inhabitants and the country has 27 States, one Federal District, 5,566 municipalities and 28 metropolitan regions (ZAMBONI & NICOLODI, 2008).

[2] In the last two decades, 216 municipalities in Brazil have registered at least five deaths on a year basis due to intense precipitation events. Many of these cities are located in less than 100 Km from the coastline.

[3] The State of São Paulo has the biggest population within the Brazilian States (more than 40 million people). It encompasses the biggest industrial complex and the most important economic activity accounting for more than 30% of Brazil's GDP. Although its economic participation has been decreasing in the last few years due to the necessary development of other regions of the country, the State of São Paulo is still considered being the richest State in the Federation, possessing the highest social-economic indicators and standards of living (SEADE, 2006).

[4] More than 50% of the private residences on the Northern coast are dedicated to tourism activities, basically second residences (*veraneio*).

[5] In 2009, several news media reported that average temperatures during the summer season have reached historic records influenced by the El Niño/La Niña South Oscillation (ENSO).

[6] See Mello et al. (2010) for the detailed methodology applied in the study.

[7] Detailed analysis of this discussion can be found in BORELLI (2008) and SMA (2009).

[8] The state government has received a loan from the Inter-American Development Bank (IADB) of more than US$ US$ 160 millions to map risk areas along the *Serra do Mar* and resettle six thousand families that currently reside in informal and illegal settlements on the Northern coast. This initiative will be complemented by investments from the State Secretary of Housing that amount to US$ 310 millions. It is estimated that 24 thousand people will be benefited by these measures in the coming years, a little less than 10% of the total population of the region.

[9] This responsibility is also shared with the state and national levels that are also in charge of coastal management and zoning.

[10] See Fernandes (2007a; 2007b) for detailed analyses of these processes in Brazil.