**RESEARCH ARTICLE**

# Coastal Cities and Climate Change: Urbanisation, Vulnerability and Adaptive Capacity on the Northern Coast of the São Paulo State, Brazil

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## Abstract

This paper examines how exposure to both socio-economic and environmental stressors and the interaction between the two affect the population of the Northern coast of the São Paulo State, Brazil. It provides a useful way to examine the multiple and overlapping processes of environmental and social-economic change. Pathways to increased vulnerability are multidimensional, so that socio-economic conditions may mediate the impacts of environmental change, but changing environmental conditions may also alter socio-economic capacities to maintain particular livelihood strategies. By analysing the region, this paper argues that the adaptive capacity is, in general, largely determined by the socio-economic context and the social vulnerability. The finding indicates that socio-economic change brought about in the last four decades due to intense urbanisation, tourism exploitation and increasingly economic activities have deepened social and environmental problems, increasing the vulnerability of particular groups to climate variability and change. The cross-scale nature of the problems and the cross-level interactions of these processes pose significant challenges for governance structures and institutions in place in the region that fail to address the root causes of vulnerability and the consequences of a changing environment and climate.



## Keywords

climate change; vulnerability; adaptive capacity; adaptation; Northern coast; São Paulo; Brazil


## 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. The natural biodiversity of these places illustrated by the presence of coral reefs, mangroves, beaches and dunes make coastal areas of particular relevance in both socio-economic and ecological terms (Crossland et al., 2005; MEA, 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. However, during the last decades, unprecedented rates of urbanisation and population growth have become major drivers of environmental change in these areas. 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 (Adger, 1999; Crossland et al., 2005)

In Brazil the situation is not different. The country has many of its major cities located on a coastline of more than 8,600 km that encompasses around 20% of Brazilian population distributed within 17 states, 395 municipalities and 16 metropolitan regions[1] (Zamboni and Nicolodi, 2008; Neves and Muehe, 2008). Although historically noticed, the agglomeration of population along the Brazilian coast has been intensifying in the last decades due to three main drivers of development patterns: urbanisation, industrialisation and tourism exploitation (Borelli, 2008; Zamboni and Nicolodi, 2008).

Increasing scientific evidence suggests that global warming due to anthropogenic emissions of greenhouse gases (GHG) 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). Future SLR has been already recognised as one of the more certain consequences of climate change through the twenty-first century, posing new risks to coastal socio-ecological systems that face continuous stress (Crossland et al., 2005; Nicholls and Tol, 2006; Nicholls et al., 2007).

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 predisposed to natural subsidence (Nicholls and Tol, 2006). Kron (2008) goes further by proposing that coastal zones are the riskiest places on the planet. In this direction, it is possible to argue that climate change poses serious risks to coastal areas, their population, habitats, and natural resources (IPCC, 2007; Nicholls et al., 2007; Neves and Muehe, 2008; Nicolodi and Petermann, 2010).

Although there is mounting concern over climate change and its impacts at 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, environmental degradation and the impacts of short-term climate variability and extremes (Kron, 2008; TCU, 2009, Mendonça, 2010).

In the São Paulo State, 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; Mendonça. 2010; Vieira et al., 2010). With no other option, these groups typically occupy the most marginal land (e.g. urban fringes and the slopes of the *Serra do Mar*) that are usually considered risk-prone areas not only to climate-related events, but also to pollution and diseases. Additionally, Brazil as one of the top emerging economies in the world has been receiving a number of private and public investments, particularly concerning large-scale infrastructure projects. This reality is shaping the present and future of Brazilian coastal areas as they are being marked by significant interventions in the last few years.

Current responses to climate variability and change are traditionally addressed more as post-disaster assistance rather than disaster preparedness and long-term adaptation as the other necessary measures to enhance the adaptive capacity of the communities. Improving the capacity of not only Brazilian coastal cities and its communities, but also elsewhere in the developing world, to reduce current vulnerabilities to climatic events has been advocated to be the most appropriate strategy to increase resilience to the potential impacts of unavoidable climate change (Adger et al., 2005; Smit and Wandel, 2006; Ericksen et al., in press).

This paper examines the current and future vulnerability to climate variability and change as well as

it discusses the adaptive capacity of the four coastal cities located on the Northern Coast of the São Paulo State, Brazil to address climate risks, with the objective of integrating appropriate adaptation and risk management strategies into the existing urban development and planning within the context of sustainable development. More specifically, the study seeks to identify and examine why some groups are vulnerable to the impacts of climate variability and change. The paper explores how exposure to both socio-economic and environmental/climatic stressors and the interaction between them affect the municipalities of the region.

The research shows that while climate variability and change is expected to impact the region, its effect will be influenced by the broader landscape of policy decisions and socio-economic changes that have been in place in the last four decades. The paper thus illustrates the need to understand local and regional situations and how they influence the capacities for current and future adaptations.

## 2 Vulnerability and the context of multiple stressors

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. In this sense, an exposed unit (e.g. household, community, city or region) is vulnerable when climate disturbance and change not only result in losses (sensitivity) 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 and Luers, 2006).

The emerging body of literature on vulnerability includes a focus on the socio-economic context, showing that it is possible to reduce impacts of climate change not just by slowing the rate of

change (mitigation) but also by reducing the vulnerability of populations (adaptation) to the ongoing transformations (Kelly and Adger, 2000; Liverman, 2001; Parry et al., 2008).

Although there are many definitions of vulnerability (Cutter, 1996; Brooks, 2003; O'Brien et al., 2007), it usually refers to the degree to which a socio-ecological system is likely to experience harm due to exposure to a hazard, or changing conditions such as climate change (Liverman, 2001; Pelling, 2003). Vulnerability is not only a result of how exposed the system is to a hazard (i.e. physical location and the character of the natural and built environment), but also how effectively the socio-economic and political attributes (i.e. policies driving urban development) can act to reduce disturbances and recover from the any impacts (Turner et al., 2003; Pelling, 2003).

The potential of a system to adjust to and limit risk is usually termed as its adaptive capacity (Smit and Wandel, 2006). This capacity can encompass a variety of adaptations, but it is used very specifically in the climate change research to denote the ability and capacity of actors and institutions to cope with climate change. Adaptive capacity thus includes preventive and reactive measures to cope with or adapt to hazard stress. It is a product of the extent of planned preparation in the light of potential hazard, and of adjustments made in response to felt hazards (Pelling, 2003).

In this direction, vulnerability analysis can thus highlight the local level with its specific contexts, and consequently examine adaptive capacity at large in a particular community or region, given that stressors such as climate change will not occur in isolation from other drivers of change such as globalisation, large-scale infrastructure investments and broader regional transformations. Accordingly, the study of climate change in this context demands an overall view of impacts and changes as they will likely influence the vulnerability of communities and regions to respond to climate change (Leichenko and O'Brien, 2008).

In order to analyse the vulnerability, it is necessary to understand the context of the system and how they are impacted by the multiple stressors. Such research endeavour also requires the means to identify which actors will be impacted and what are their roles and resources (Keskitalo, 2008).

## 3 The Northern coast of the São Paulo State, Brazil

### 3.1 *Geographic location*

The Northern coast of the São Paulo State is formed by four municipalities: *Caraguatatuba; Ilhabela, São Sebastião* and *Ubatuba* (Figure 1). 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*). Hill slopes are very steep, often more than 35-40$^{o}$. The soil of the *Serra do Mar* is naturally susceptible to erosion and landslides and the occurrence of mass movements is 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* supports one of the richest, highly diversified, and most threatened ecosystems on the planet, namely the Atlantic rainforest (*Mata Atlântica*). However, due to the intense process of deforestation and urbanisation there is only 7% of the original forest cover left, mainly in the steep escarpments facing the sea. This area is protected by national and state parks, ecological stations and other types of conservation units that account for around 80% of the total territory of

the Northern coast of the São Paulo State. The majority of these protected areas are within the borders of the *Serra do Mar* State Park that is administrated by a state foundation, and belongs to the Atlantic Forest Biosphere Reserve considered to be of extreme biological importance (SMA, 2009).

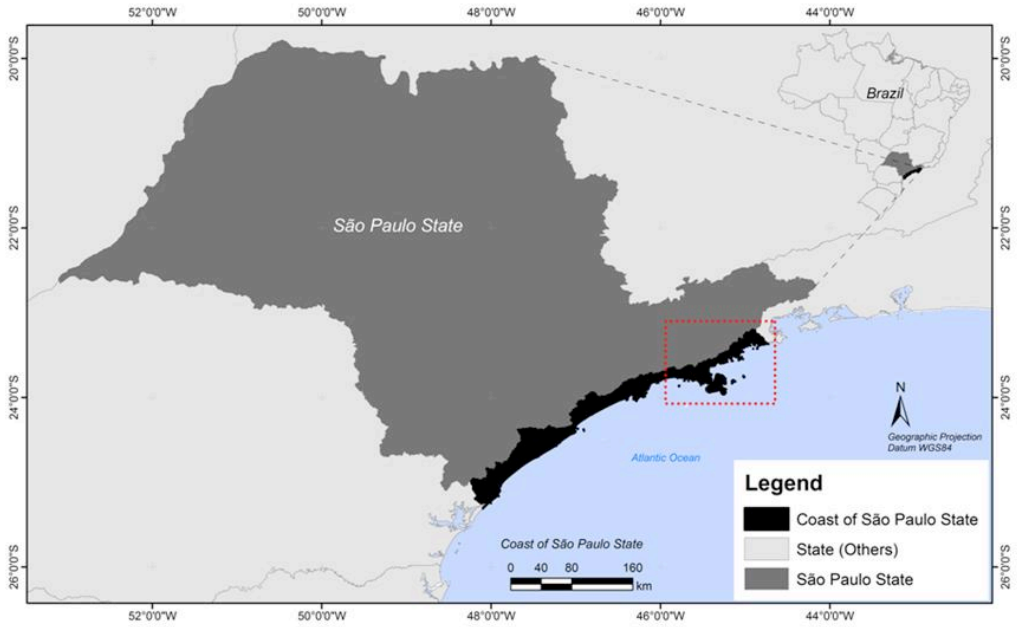


**Fig. 1 – The Northern coast of the São Paulo State, Brazil**
Source: Allan Yu Iwama de Mello (Nepam/Unicamp)

### 3.2 *Socio-economic and environmental features*

The process of human settlement on the Northern coast of the São Paulo State 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 1970s allowing the connection of the Northern coast with important axes of transport and

economic development in the São Paulo State, historically considered the most influential engine of the Brazilian economy[3] (Borelli, 2008).

The process of urbanisation began with the operation of the *São Sebastião* port in 1955 that later became a major point of oil distribution and commercialisation in Brazil when the Brazilian oil company PETROBRAS built an marine oil terminal connected to the port in the 1960s (SMA, 2005; 2009; Borelli, 2008). The improved access to the region have also stimulated the tourism exploitation building upon the remarkable natural landscape made of the presence of the *Serra do Mar*, remnants of *Mata Atlântica*, several beaches, rivers, waterfalls and islands. Nowadays tourism is considered the main economic activity of the region.

In this sense, around 50% of the private residences are dedicated to tourism activities, basically second residences. Since the 1970s, this process has led to an expansion of the real state market to supply the demand for second residences, fostering a process of intense urbanisation and the speculation of land prices without appropriate control from the municipal authorities.

These processes together made the municipalities of the region a destination for many people that were not only looking for beach houses, but also for job opportunities in the emerging regional economy. As a result, there was an increase in illegal settlements and occupation of protected areas, followed by a process of disordered urban growth, with the poor and traditional groups being pushed away from coveted areas as they did not have the financial means to pay for the rising property prices. Without housing policies and other feasible options, these groups were forced to settle in the slopes of the *Serra do Mar* even though some of these are considered risk prone areas highly susceptible to landslides. The combination of uncontrolled processes has also led to increasing levels of environmental degradation, deforestation and social conflicts between the new

settlers, tourists and traditional communities (Borelli, 2008).

There are still some traditional communities (e.g. caiçaras) that have their livelihood based on artisanal fishing. Artisanal fishing has been facing many challenges in the last decades and some fishermen are being forced to change their occupation as fish catch are decreasing possibly due to the increasing port activity and high levels of pollution and environmental degradation. There are some pilot projects in place trying to improve the social-economic condition of these groups.

More recently, despite the clear profile for second residence tourism and port activities, important gas and oil reserves in the pre-salt layer located within the coast of the São Paulo State have repositioned the region to receive major infrastructure investments to allow the exploitation of these resources (SMA, 2009). Since 2008, a number of initiatives carried out by public and private agents have started to be planned and developed in the region. This includes the construction of industrial complexes, pipelines, offshore platforms and a permanent gas treatment plant in the municipality of *Caraguatatuba* also under responsibility of *PETROBRAS*.

In *São Sebastião*, the port is likely to be enlarged in order to be able to handle the increasing supply of oil and its products. There are also various other projects being coordinated by the state government in partnership with the national government and private investors seeking to expand the logistic capacity and the accessibility of the region through the improvement of transport facilities and the enhancement of public equipment (i.e. detention centre and hospital facility) preparing the Northern coast for a new cycle of expected urban growth and increasingly economic activities. These investments are likely to influence the socio-economic dynamic and the regional landscape although it is too early to notice or assess major changes besides those that have been already taking place in the last four decades.

Preliminary projections show that some municipalities may face major changes and therefore critical challenges in terms of future sustainability as they already face stressed social-ecological systems (*e.g.* Caraguatatuba and São Sebastião) while others may experience fewer impacts in the short- and medium-terms (SMA, 2009). In the long-term there are still many uncertainties and widespread indeterminacy on how the region will be affected by these ongoing development interventions in the future.

### 3.3 *Population dynamic*

The four municipalities have experienced considerable population growth in the last four decades as result of urbanisation and economic development. The rising number of second residences, hotels and the port activities has generated the demand for a number of services, attracting migrants from other Brazilian states (Borelli, 2008). In order to illustrate this situation, the population of the region in 1950 was roughly 24,300 inhabitants. In 2010, conservative estimates indicate approximately 275,000 inhabitants (SMA, 2009). As the Table 1 shows, the period between 1960 and 2010 represent a significant increase in the population of the region. The rates of population growth rank among the highest in the São Paulo State during the covering period.

**Table 1 – Population and population growth on the Northern coast of the São Paulo State**

| Municipality | Total Population | | | | | | | Geometric Rate of Annual Population Growth (% per year) | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1950 | 1960 | 1970 | 1980 | 1990 | 2000 | 2010* | 1980/1991 | 1991/2000 | 2000/2005 |
| **Caraguatatuba** | 5,400 | 9,800 | 14,300 | 33,483 | 50,569 | 78,628 | 91,397 | 4,17 | 4,56 | 3,46 |
| **Ilhabela** | 5,000 | 5,100 | 5,800 | 7,743 | 12,797 | 20,752 | 27,690 | 5,13 | 4,95 | 4,06 |
| **São Sebastião** | 6,000 | 7,400 | 12,300 | 18,839 | 31,770 | 57,745 | 71,290 | 5,35 | 6,26 | 4,88 |
| **Ubatuba** | 7,900 | 10,200 | 15,400 | 26,927 | 44,683 | 66,644 | 84,137 | 5,18 | 3,97 | 3,18 |
| **TOTAL** | 24,300 | 32,500 | 47,800 | 86,990 | 139,820 | 223,770 | 274,510 | | | |

Source: SEADE (2006).
(*) Estimated population

As tourism remains the main economic activity of the four municipalities, the temporary population

of the region during the summer season can go up to one million people. This reality brings many challenges for providing basic public services as the regional infrastructure is not designed for this population agglomeration. Municipal governments and local administrations have been active in trying to limit the number of people during the high season (i.e. buses restriction and visitors fee), but still face many difficulties to provide visitors, temporary and permanent residents with the basic services such as solid waste collection and disposal, public transport, and traffic control on overcrowded streets, avenues and roads.

### 3.4 *Climate and Extreme Events*

The region is located at the 23$^{o}$S in the Brazilian humid tropical zone. The climate of the region is characterised by annual average temperatures of 20C and periods of intense rainfall (summer) alternated with a period of lower rainfall (winter) that present orographic influences (Furian et al., 1999; Vieira et al., 2010). The rainy season occurs from December to March, and concentrates 60-70% of the average total annual precipitation. The average of total annual rainfall for the most representative meteorological stations of the region is about around 2000-2500 mm, being considered one of the rainier areas in the Brazilian Southeast (Vieira et al., 2010).

The region has already experienced a number of extreme events over the last few decades such as the '1967 catastrophe' that took place in *Caraguatatuba*, on 18 March 1967, when the slopes of the Serra do Mar received heavy rainfalls of more than 580 mm in two days, collapsing the soil and causing hundreds of landslides and debris flows[4]. Around 400 casualties were reported, although some elder residents claim that many more have died in the disaster. In addition, some neighbourhoods of the city were completely destroyed and most avenues, streets and roads were totally disrupted for many weeks, isolating the region.

Today, the area that was destroyed by the disaster – considered of very high risk – has been occupied by illegal settlements and invasions. The municipality of *Caraguatatuba* alone estimates that around 800 people live in 19 risk areas that encompass 29 households with very high risk of collapsing, a problem that is widespread on the Northern coast municipalities.

## 4 Projected impacts of climate variability and change

### 4.1 *Temperature*

To date there are no specific assessments available that model or project future climate changes in the coast of the São Paulo State, although there are some research projects underway that are expected to provide climate projections for the region in the coming years[5]. However, a number of previous studies have projected climate change and its possible impacts for the São Paulo State and the Brazilian Southeast region, mostly based on the analysis of temperature and rainfall patterns (*i.e.* Marengo et al., 2007a).

These studies have shown that average, minimum and maximum temperatures are likely to increase over the 21st century as a result of global warming. Building on global climate models and using downscaling methods, Marengo (2007) projected an increase of 2C up to 3C in average temperature for the Brazilian Southeast region by 2100. Although still surrounded by a considerable degree of uncertainty, these studies corroborate with the widespread global and regional (South America) climate change projections that expect an increase in average temperatures with possible changes in the minimum and maximum temperatures (IPCC, 2007; Marengo, 2007; Marengo et al., 2007b).

### 4.2 *Extreme events*

There are also some few studies available that highlight a possible increase in the frequency and magnitude of extremes events within the twenty-first century in the region although they also encompass high levels of scientific uncertainty (Salati et al., 2007). It is also important to stress that these results still face barriers to support and influence policy making and the interaction between the scientific community and policy makers in the region can be considered low, although some initiatives have been taken more recently to improve the science-policy interaction.

On the other hand, the region can be already considered vulnerable to climate variability, particularly the El Niño/La Niña South Oscillation (ENSO). Extreme events such as storms and heavy precipitation events have been a major source of attention and concern for government authorities and the local communities as they can trigger landslides and mass movements. Due to the process of urban growth and the common land use pattern that has been cited above – where some (poor) people were pushed into risk prone areas – the extent of climate change are of great interest of authorities and community leaders (Marengo, 2007).

Extremes events can be defined as climate anomalies that occur in time scales that can vary from days up to millenniums (Marengo et al., 2007b; Mendonça, 2010). Despite the great uncertainty in modelling its changes, short-term extreme events have been considered a major issue by climatologists within the Brazilian and South American scientific communities. Recent projections undertaken by South American scientists have indicated an increase in the frequency and intensity of short-term extreme events, particularly extreme hydro-meteorological events, which are primary sources of natural disasters in Brazil (Marengo et al., 2007b). Within the context of the Northern coast, the consequences of these extreme events are always materialised in the form of losses and

casualties due to the very frequent landslides in the slopes of the *Serra do Mar*, particularly among the poor groups (Furian et al., 1999).

### 4.3 *Sea-level rise and coastal erosion*

Another major issue of interest and concern is SLR. Studies have shown that the sea level is rising along the Brazilian coast (Mesquita, 2004; Muehe, 2006; Neves and Muehe, 2008). Some estimates suggest that the sea level has already risen 40 cm in the last 100 years (Mesquita, 2004) and is expected to raise more as projected by many scholars and the Intergovernmental Panel on Climate Change (IPCC, 2007). In the São Paulo State, different locations of its coastline have already been flooded or are suffering from high levels of coastal erosion, particularly on its Northern portion, as it has been reported by Souza (2003; 2009) and Borelli (2007). With SLR, coastal cities in Brazil are likely to face new risks and its effects have the potential to undermine livelihoods, essential services and economic development (Ribeiro, 2009).

Although SLR and coastal erosion are long-term natural processes, human activities combined with changes in the global climate system can amplify its pace and consequences in Brazilian coastal zones (Souza, 2003; 2009; Muehe, 2006; Neves and Muehe, 2008; Zamboni and Nicolodi, 2008; Nicolodi and Petermann, 2010). Societal responses to SLR can also be taken in the long-term, but they are likely to be costly if not acting early. Therefore, it is almost certain that the necessary measure will exceed the financial capacity of most municipal governments located on the Brazilian coast and are likely to be difficult to implement due to the different interests that are and will be in place.

Based on IPCC emission scenarios (B2 and A2), recent estimates proposed by Margulis et al.

(2010) have indicated that material losses within Brazilian coastal zones could range between US$ 75 and 115 billion. The authors argue that the cost of basic adaptation measures that could limit losses and deaths in the long-term would not exceed US$ 2 billion if implement until 2050 (Margulis et al., 2010). Even though the figures and the adaptations measures themselves are still very preliminary, it shows that the investment for planned adaptation is less than 3% of the total material loss projected[6]. However, the municipalities located on the Northern coast do not have the technical, financial and even political capacity to undertake these measures without strong commitment and support from higher levels of governance (*e.g.* state and national).

## 5 Existing vulnerability and adaptive capacity of coastal cities to address climate risks

### 5.1 *Socio-environmental vulnerability to climate variability and change*

Among the major social groups located on the coastal cities analysed that can be affected by climate variability and extremes, SLR and future climate change are low-income families, although some middle- and high-income households can also be affected (mainly in *Ilhabela* and *Ubatuba*). The low-income groups are composed by artisanal fishermen and people that work in the municipalities usually in the construction sector or doing cleaning and housekeeping for the second residence houses and landlords. In general, they possess small capital assets, low-income and less education, living in informal settlements that are considered to be more exposed to climate events (Borelli, 2008; SMA, 2009; Mello et al., 2010).

The middle- and high-income households are mainly composed by people that live in bigger urban centres (*i.e. São Paulo* or *São José dos Campos*) and go to the beach houses during the weekends, holidays or summer season. They can also be permanent residents or contract workers that are

living in the municipalities due to the port activities and the emerging oil and gas industry that is bringing a number of infrastructure investments to the region with figures that can easily reach US$ 10 billion dollars in the next decade. These people enjoy bigger capital assets and live in solid house structures and developed settlement areas which are located in places that are in general less vulnerable to flooding or landslides. However, most of losses and casualties reported so far in the region are mainly concentrated within those that belong to the low-income groups.

Previous analyses that consider the impacts of climatic events in the region have been showing that the vulnerability of social groups to climate variability and change, including SLR, vary disproportionately among them (Mello et al., 2010). In general, the families that are better-off have improved coping mechanisms than the other groups and therefore can be considered as being less vulnerable by having higher adaptive capacity. Those who have been bearing the highest impact of climate events until now are clearly those with poor coping mechanisms, which lack the assets and the means to respond effective to these events, particularly the heavy rainfalls that can trigger landslides within the slopes of the *Serra do Mar*. It is also important to stress that the more these groups are dependent on natural resources to sustain their livelihoods, the more they have less capacity to respond to climate risks, raising important considerations on how the municipal governments within the region could provide them with sustainable options based on technical and social assistance to enhance their opportunities in long-term.

The areas considered of high and very high vulnerability are typically those located in less than 500 m from the coastline (exposure to SLR) or in the slopes of the *Serra do Mar* (more than $30^{o}$) where most of the low-income groups reside (exposure and sensitivity to landslides). Mello et al. (2010) have estimated that roughly 28% of the population is exposed to SLR and more than 30% of the population is living in risk areas susceptible to landslides[7].

Another issue that deserves consideration is the socio-economic status of the region. Although the São Paulo State ranks among the highest socio-economic indicators when considering all the Brazilian states, the four municipalities of the Northern coast are below the state's average in a number of indicators such as death rates, per capita income, GDP per capita, illiteracy, life expectancy, health care and homicides among others (Borelli, 2008; SMA, 2009).

The way that the region has developed – fast and without plan and control – has brought serious social-environmental challenges. At the same time, the lack of adequate sanitation infrastructure brings various health problems for the population and degradation to the environment compromising the future of tourism, leisure and recreation in the region (Borelli, 2008). The table 2 shows the summary of the sanitation situation in the four cities of the region.

**Table 2 – Sewage collection on the Northern Coast of the São Paulo State in 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) and based on SABESP (2008).
(*n/a*) indicates that the data is not available

The analysis of the above table shows that only the minority of the people living in the region has access to proper sewage collection and treatment. Mello et al. (2010) highlight that this limited access to basic sanitation is not in compliance with the National Sanitation Act (Law 11.445, 5 January 2007) and that the illegal disposal of sewage can cause soil and water pollution, with

serious social and environmental consequences. Although there are important facilities planned or under construction, it is clearly not enough vis-à-vis with the level and nature of the ongoing investments and expected development. It is also important to notice that many of these interventions are still not considering climate change in its plans. However, some studies are starting to show that SLR might have an important impact on the sanitation systems along the Brazilian coastline and there is widespread lack of awareness to this and other climate change issues in these coastal zones (Neves and Muehe, 2008; TCU, 2009).

### 5.2 *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 and Ferreira, 2010; Ferreira et al., 2011). However, the four cities that compound the Northern coast of the São Paulo State have been trying to implement some adaptation strategies in order to minimise the adverse effects of climate variability and change on the coastal communities. These include information campaigns and raising awareness of those who live in highly vulnerable areas; relief assistance and evacuation; and resettlement of some vulnerable families to safer areas are expected in the coming years[8].

Although these measures can generally reduce the vulnerability of some people to the undesirable impacts of climatic change, they fail to address the root causes of vulnerability. In this sense, it is possible to argue that the capacity to implement adaptation to climate change is also determined by the economic and the political context (Keskitalo, 2008). There exist a number of different contextual factors related to ongoing socio-economic changes that further impact the adaptive capacity of the four cities and its communities to undertake adaptations to climate change. Usually,

the main adaptive capacity is related to the resources available in the broad sense, which include their financial and societal resources, benefits, and available strategies. Adaptive capacity is thus fundamentally dependent upon the resources of those who must adapt.

Adaptation can take place through changing institutions and management strategies (Martins and Ferreira, 2010). One example is the Civil Defence Plan that the São Paulo State have been implementing in partnership with local governments that have more people living in risk areas. On the Northern coast, there has been implemented a Civil Defence Preventive Plan (PPDC in Portuguese) that seeks to provide the municipal governments with the instruments and strategies to reduce the number of losses and casualties resulting from landslides during the rainy season. The plan is based on a variety of actions that include monitoring of risk areas, capacity building, warning systems, and evacuation strategies.

Due to the complexity of the problem caused by the form and pace of the urbanisation process and the recognition that local governments in this area cannot address the problems in short-term, the plan consists in a way of dealing with the situation without being able to address the main sources of vulnerability and risk. Major investments and fundamental actions from higher levels of governance would be necessary to provide a long-term and sustainable adaptation strategy (Eriksen et al., in press).

Municipal governments in Brazil have a number of competences and jurisdiction to implement local adaptive strategies such as to limit the development in highly vulnerable zones, to alter the land use ordinance and building code, and implement (partially) coastal zoning[9] (Martins and Ferreira, 2010; Ferreira et al., 2011). Based on discussions with policy makers, Table 3 shows a list of possible local adaptive strategies that could be implemented by the local governments on the

Northern coast of the São Paulo State.

**Table 3 – Possible adaptive strategies for the municipalities located on the Northern Coast of the São Paulo State**

| Response option | 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 and enforce the strict implementation of this ordinance/code; |
| | (Partial) coastal zoning; |
| | (Partial) protection of threatened ecosystems; |
| | Regulation of ecological risk zones; |
| ***Protection (defence of vulnerable areas, population centres, economic activities and natural resources)*** | Improvement/construction of existing road, 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; |
| | Afforestation/reforestation of upland areas; |
| ***Other proposed adaptive and capacity-enhancing strategies*** | Implementation of disaster risk reduction; |
| | Implementation of information campaigns to raise the community awareness; |
| | Strengthening municipal civil defence coordination; |
| | Provision of adequate technical, training, financial and organisational 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 interviews.

However, the municipal authorities are not making use of the available institutions and policy instruments to deal with the problem and therefore reduce the vulnerability of specific social groups. For instance, one of most important instruments that could be mobilised to respond effectively to the regional problems (i.e. informal and illegal settlement and exposure to climate and environmental hazards) is the Participatory Municipal Masterplans (PMM) that was proposed in the 1988 Federal Constitution and came into effect after being regulated by the 2001 Statute of the City (Law 10.257)[10] (Fernandes, 2007a).

The Statute of the City stated that all municipalities with more than 20,000 inhabitants were given a deadline of five years (10 October 2006) to create and approve their PMM. The PMM is one of the fundamental instruments at the municipal level, setting the basis for strategic development and urban planning. The objective is to set the guidelines and regulate land use, zoning and public budget priorities for promoting social justice and urban infrastructure through access to public services and social policies, including housing.

Among the municipalities of the Northern coast, only *Ilhabela* and *Ubatuba* (the smaller ones with clear touristic profile) have approved their PMM, although without explicit consideration to the problems that are directly affected by climate variability and change. *São Sebastião* and *Caraguatuba* – with the port and oil and gas facilities – did not meet the deadline stated in the Statute of the City. These municipalities are still formulating and discussing their masterplans with fierce debates being held at the Local Councils. As argued by Goulart (2008), institutions count but politics make the difference in the approval of PMM. The discontinuity in local politics combined with powerful private interests is undermining the process and the possibility for clear guidelines that could change the situation in both cities.

Additionally, Ferreira et al. (2011) show that these cities present secretariats, departments, directories and other types of governmental bodies as well as social and environmental legislation that are available to be mobilised in future climate change actions. However, the existing structures and the alternatives that have being proposed until now by these institutions are far from sufficient to respond effectively to the magnitude and complexity of the climate change problem.

As the debates and decisions taken by different actors and levels of governance have been determining the future of the region, there are reasonable arguments to defend the social

engagement in collective and political dialogues, negotiation and proposals that could enhance the response and adaptive capacity of the municipalities to address the challenges arising from climate variability and change. It is essential to get away from the traditional measures deployed by Brazilian local governments that are merely palliative. In this sense, policy and institutional responses have to go beyond reformist views that do not address the root causes of vulnerability to climate variability and change that are shaped by the social injustice, private interests and unsustainable patterns of economic development.

## 6 Conclusion

This study illustrates the large impact of socio-economic transformations and the path dependency to former political and policy decisions that have affected the vulnerability and adaptive capacity of a particular region, namely the Northern coast of the São Paulo State, in terms of its capacity to address the effects of climate variability and change. The socio-economic change that has driven the rapid process of urbanisation, population growth and the economic activities (e.g. second residence tourism, port activities and oil and gas industry) needs to be understood in terms of both local and regional context and the capacities for planned adaptation.

The study shows that climate variability and change is expected to continuously impact the area that is already facing different 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. The exponential population growth combined with poor basic infrastructure have created a situation where the most vulnerable social groups are living in high risk areas susceptible to landslides, environmental degradation and poor quality of life. In additional, the lack of municipal control, law enforcement and adequate urban planning has led to a condition of rising

exposure to climate and environmental hazards such as SLR, coastal erosion, vector borne diseases and landslides triggered by heavy rainfalls. Global climate change combined with natural climate variability is expected to worsen the situation accordingly to preliminary assessments.

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 and communities to respond effectively to climate change. There is an urgent need to improve and build the capacity of the municipal governments of the four cities so that they can formulate and implement appropriate adaptation and risk management strategies within the existing urban development.

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. In this sense, the possible adaptation strategies discussed in this paper will only be 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 do not address climate change adaptation specifically, but they provide interesting opportunities for reducing vulnerability and enhancing the adaptive capacity through better urban planning and sustainable development pathways.

The major socio-economic change shows the importance of viewing climate change in the context of multiple stressor and other ongoing developments and trends. Climate variability and change represents an additional stressor to already vulnerable communities. The paper indicates not only levels of vulnerability, but also particular aspects of vulnerability where external amelioration strategies could be directed toward the disadvantaged social groups, bringing to light the relative

importance of such issues for the communities that are fundamental 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 and Nicolodi, 2008).

[2] In the last two decades, 216 municipalities 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 São Paulo State 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 São Paulo State is still considered being the richest State in the Federation, possessing the highest social-economic indicators and standards of living (SEADE, 2006).

[4] For a recent analysis of two of these extreme events, see Castro et al. (2010).

[5] It refers to the Global Climate Change Programme, *Fundação de Amparo à Pesquisa do Estado de São Paulo* (FAPESP).

[6] Human casualties were not considered in the study.

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

[8] The state government has received a loan from the InterAmerican Development Bank of US$ US$ 162,4 million 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$ 307,7 million. 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.