

Double Exposure on the Northern Coast of the São Paulo State, Brazil

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Abstract

This paper examines how double 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 based on the conceptual and analytical framework developed by R. Leichenko and K.L. O’Brien. It provides a useful way to examine the multiple and overlapping processes of global change and, in particular, the places and the ways in which the economic and the non-economic interact. Interactions between economic and environmental change shape local landscapes of vulnerability and a major challenge for understanding vulnerability involves identifying how economic and environmental processes interact in particular places and how these interactions shape the effects of some global change processes and drive others. 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 case studies of four municipalities that compound the region we found that people’s resilience, in general, are largely determined by the socio-economic context and the social vulnerability. Our findings indicate that socio-economic change brought about in the last three decades due to intense urbanization, tourism exploitation and increasingly economic activities have altered people’s livelihood and deepened social problems. We argue that the cross-scale nature of the problem 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 roots of vulnerability and consequences of a changing environment.

Keywords

Climate change; vulnerability; adaptive capacity; adaptation; local governance

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DRAFT VERSION – TO BE UPDATED BEFORE THE CONFERENCE

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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 twentieth century the level of disturbance to natural process did not appear to be critical. However, during the last century, urbanisation and population growth have become major drivers of environmental change in these areas. Not surprisingly, the continuing and unsustainable use of coastal areas has led to a variety of environmental degradation, habitat destruction and pollution raising the 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 up to 20% of Brazilian population distributed within 17 different States, 395 municipalities and 16 metropolitan regions² (IBGE, 2000; Neves and Muehe, 2008). Although historically noticed, the agglomeration of population along the Brazilian coast has been intensifying in the last few decades due to three main drivers of development: urbanisation, industrialisation and tourism exploitation (Moraes, 1999; Zamboni and Nicolodi, 2008).

Despite the main drivers of development and environmental change taking place on coastal zones, there is increasing scientific evidence that suggests that global warming due to anthropogenic emissions of greenhouse gases are having a discernible effect on the Earth's climate (Steffen et al., 2004; IPCC, 2007; Solomon et al., 2007; Rockström et al., 2009). These effects are expected to intensify a range of climate aspects, including acceleration in global sea-level rise (SLR), which can have critical impacts on coastal areas in general (Solomon et al., 2007; Nicholls et al., 2007). In this sense, future SLR has been recognised as one of the more certain consequences of human-induced

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² 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 (IBGE, 2000).

climate change through the twenty-first century posing new risks to already stressed coastal areas (Nicholls and Tol, 2006; Nicholls et al., 2007).

Likewise, it is not only SLR, but also the possibility of more intense storms and extreme 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). In this direction, one can argue that global climate change poses serious risks to coastal zones, their habitats and resources. Although there is mounting concern over climate change and its impacts at the global and national levels, coastal cities in Brazil (and in most of the global South) face a number of more urgent problems such as development deficits, sustainability challenges and the impacts of short-term climate variability and extremes (Sales Jr., 2009).

In Brazil, the poor communities located in the coastal areas are among those who bear most of the harmful effects of natural hazards in general, which include flooding, loss of coastal lands, coastal erosion and landslides. With no other option, these groups typically occupy the most marginal land (e.g. urban fringes) that are usually considered risk-prone areas not only to climate change, but also to pollution and diseases (Hogan and Marandola Jr., 2007). Additionally, Brazil as one of the emerging economies in the world has been receiving a number of private and public investments, particularly concerning large-scale infrastructure projects. In this sense, the present and future of Brazilian coastal areas are being marked by significant interventions.

However, the issue of climate change, variability, and extreme events is not of main concern in the Brazilian municipal governments next to the coast when compared to more pressing social development concerns such as employment, education, health care and housing. Current responses to climate variability and change are addressed more as disaster preparedness and mitigation options rather than as the necessary measures to facilitate long-term adaptation.

Enhancing the capacity of not only Brazilian coastal cities and its communities, but also elsewhere, 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; Füssel, 2007).

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 State of São Paulo, Brazil to address climate risks, with the objective of integrating appropriate adaptation and risk management strategies into the existing urban development within the context of sustainable development for the region. 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 the two affect the municipalities of the region. Finally, it also discusses how these vulnerable groups can be affected by climate change in the future.

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

2 The Northern coast of the State of São Paulo: multiple socio-economic and environmental/climatic stressors

2.1 Geographic and socio-economic background

The Northern coast of the State of São Paulo is formed by four municipalities: Caraguatatuba; Ilhabela, São Sebastião and Ubatuba (fig. 1). The region's landscape is marked by the Serra do Mar, a long system of mountain ranges and escarpments in South-eastern 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). The mountain is discontinuous in several places and also extends itself to some large islands near the coastline such as Ilhabela and Ilha Anchieta (that belong to the municipality of São Sebastião). The Serra do Mar used to support one of richest and highly diversified ecosystem in the world: the Atlantic rainforest (Mata Atlântica). However, due to urbanisation and deforestation, there is only 7% of forest cover that remains almost exclusively in the steep escarpments facing the sea. These areas are now protected by a number of national and state parks, ecological stations and conservation units, although there are still many pressures, particularly on areas close to the urban centres (SMA/CPLA, 2009).

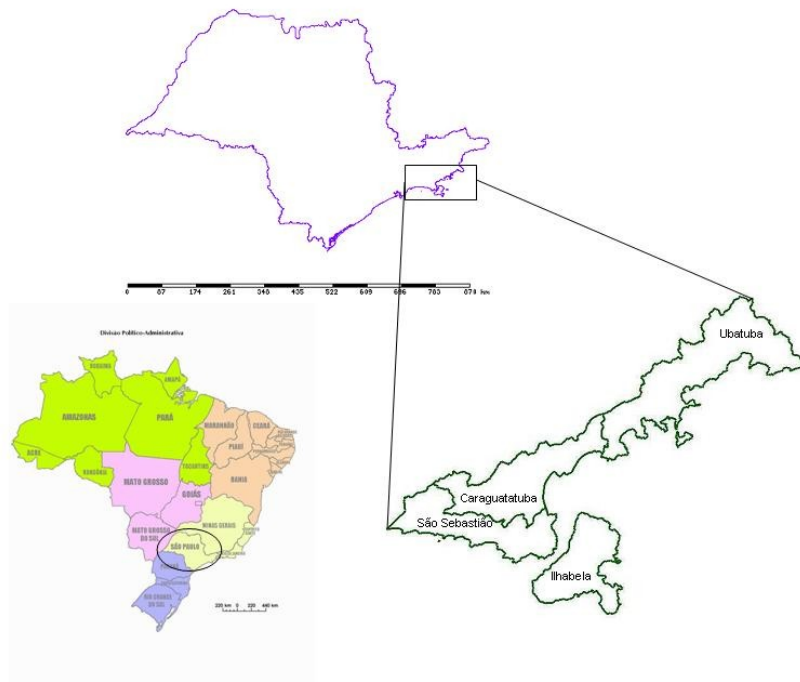


Fig. 1 – The Northern coast of the State of São Paulo, Brazil

The process of human settlement on the Northern coast of the State of São Paulo dates back to the colonial time although significant economic activities have only been seen after important roads (e.g. Rod. Oswaldo Cruz, Rod. Rio-Santos, Rod. dos Tamoios) were built during the 1970s allowing the connection of the Northern coast with important axes of transport and economic development in the State of São Paulo, historically considered the most influential engine of the Brazilian economy³. 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 (Borelli, 2006, see fig. 2). The expansion of the real state market during this period to supply the demand for second residence tourism fostered the process of urbanisation and the speculation of land prices without proper control from the municipal authorities. Until today, the tourism activity is considered the main economic activity of the Northern coast of the State of São Paulo. In this sense, more than 50% of the private residences in this region are considered for tourism purposes, namely second residence, accordingly to official data (IBGE).

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).



Fig. 2 – The Northern coast landscape

The process of urbanisation was combined with the establishment of the São Sebastião port – located in the municipality with the same name - that became a major point of oil distribution and commercialization since the 1960s (SMA/CPLEA, 2005; Borelli, 2006; SMA/CPLA, 2009; see fig. 3 and 4). These overlapping processes – urbanisation, tourism exploitation based on second residence and different forms of economic development – shaped the regional dynamic and the region’s landscape. Even though the region has been changing considerably over the last years, more than 80% of its territory is still protected by different conservation units under responsibility of the three levels of government in Brazil (local, state and national). The majority of these protected areas are within the borders of the Parque Estadual da Serra do Mar that is administrated by the state government.

Over the last few decades, the municipalities of the region have been the destination of 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 constructions 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. Without options, these people were forced to settle in the slopes of the Serra do Mar even though some of these are considered high risk areas susceptible to landslides. This combination of uncontrolled processes has also led to

environmental degradation, deforestation and social conflicts between the new settlers, tourists and traditional communities (Borelli, 2006).



Fig. 3 – The São Sebastião Port



Fig. 4 – The São Sebastião Port

Environmental assessments undertaken in the region have reported rivers and mangroves affected by high levels of pollutants due to the lack of adequate sanitation systems and landfills for solid waste management. Over the years, it is also possible to notice negative impacts on human health through an increase in diseases such as schistosomiasis, cholera, leishmaniasis, hepatitis and diarrhea (Borelli, 2006; Barbosa et al., 2009). In addition, there was more than 292 oil spills

reported within the port's operation in the period between January 1978 and June 2004, some of them being classified as of great proportion (SMA/CPLEA, 2005).

More recently, despite the clear profile for second residence tourism and port activities, important gas and oil reserves in the pre-salt layer located closer to the Northern coast of the State of São Paulo have repositioned the region to receive major infrastructure investments to allow the exploitation of these resources (SMA/CPLA, 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 by the Brazilian oil company Petrobras. In São Sebastião, the port will be enlarged to be able to distribute the oil production that is expected to begin in the coming years. Besides that, there are various other projects led by the government of the State of São Paulo in partnership with the national government seeking to expand the logistic capacity and accessibility of the region through the improvement of transport facilities and the enhancement of public equipment (e.g. detention centre, hospital, sanitation, water reservoir) so that the region could be better connected to important urban and industrial centres and sustain the urban growth and economic activities. Some major improvements in the regional sanitation system are also under way to address the deficits in terms of solid waste and sewage collection and treatment.

These investments are also expected to influence the socio-economic dynamic and the landscape of the region although this is not a uniform process and it is too early to notice or assess major changes besides those that have been already taking place in the last few decades. Preliminary projections show that some municipalities may face major changes and therefore critical challenges in terms of future sustainability (e.g. Caraguatatuba and São Sebastião) while others may experience fewer impacts in the short-term (SMA/CPLA, 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.

Conducted interviews⁴ have shown that some second residence tourists and house owners are against major changes that can reduce the region's natural potential for leisure and recreation and are organising themselves to limit the extent of these development projects (e.g. enlargement of the São Sebastião port). Small fishermen communities and traditional groups are afraid that major oil and gas activities may impact even more the natural resources in which their livelihood and well-being depends as they have already noticed the impacts of environmental degradation after years of intense urbanisation and population growth.

Municipal governments within the region hold a dual position in general. In one hand, they are concerned about the future and afraid about the extent of the changes; on the other hand, public

⁴ This material is still unpublished and is being carried out by different research groups linked to the project cited above.

officials also see many development opportunities and prospects for employment and social inclusion that could benefit the poor and raise local revenues. The considerable investments in public infrastructure such as sanitation and transport facilities are also waited with great expectation as they consider them top priorities for the cities and for the region as a whole.

2.2 *Climate*

The climate of the region is characterised by annual average temperatures of 20° C and intense rainfalls, being considered one of the rainier areas in Brazil. The region has already experienced various extreme events over the years such as the ‘1967 catastrophe’ that took place in the municipality of Caraguatatuba when the slopes of the Serra do Mar received rainfalls of more than 420mm in a single event causing the collapse of the soil. Around 500 casualties were reported, although some elder residents claim that many more have died. In addition, some neighbourhoods of the city were completely destroyed and most avenues, streets and roads were totally interrupted for weeks.

2.3 *Population*

The four municipalities of the Northern coast have experienced considerable population growth, particularly in the last four decades, as result of urbanisation and economic development. In order to illustrate this situation, the population of the region was roughly 24,300 inhabitants in 1950. In 2010, estimates indicate approximately 275,000 inhabitants. As the table 1 shows, the period between 1960 and 2010 represent a significant increase in the population of the four cities. The geometric rates of annual population growth rank among the highest in the State of São Paulo during the above mentioned period. In this sense, the average of annual population in the region (Northern coast, four municipalities) was 4,84 for the period 1980/1991; 4,83 for 1991/2000; and 3,81 for 2000/2005. In the same period, the average for the State of São Paulo was 2,12; 1,82 and 1,56 respectively.

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

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: IBGE; SEADE

(*) Estimated population

As tourism remains the main economic activity of the four municipalities, the temporary population of the region during weekends, summer time and holiday season can go up to one million people at a time. This reality brings many challenges not only for local sustainable development, but also for providing public services as the regional infrastructure is not designed for such a population agglomeration. Municipal governments and local administrations have been active in trying to limit the number of people during the considered high season, but still face many difficulties to provide visitors and residents with the basic services such as solid waste collection and treatment, and traffic control on overcrowded streets, avenues and roads.

Additionally, there are still some traditional communities (e.g. caiçaras) that have their livelihood based on artisanal fishing particularly in the municipality of Caraguatatuba⁵. Artisanal fishing has been facing many challenges in the last few 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. Some of the fishermen, particularly the elderly, reported that they have been also noticing climatic changes in the last years that could have had an impact on the fish stocks leading to the decline of fish catch although there is lack of sound scientific data available at the moment to support these statements.

3 Vulnerability of the Northern coast to the projected impacts of climate change and variability

Recent work and scholarship among global change researchers has shown an emphasis on vulnerability and the extent to which systems can adapt to and thereby deal with change. In this sense, an exposed unit (e.g. a household, community, city or region) is vulnerable when climate

⁵ The most important communities are Massaguaçu, Camaroeiro and Porto Velho.

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; Eakin and Wehbe, 2009).

The emerging body of literature on vulnerability includes a focus on the socio-economic context, showing that it is possible to reduce impacts of global change not just by slowing the rate of climate change (by mitigation) but also by reducing the vulnerability of populations to these ongoing changes (Liverman, 1990; Kelly and Adger, 2000). In this direction, some authors have argued that these different interpretations of vulnerability - where the word vulnerability means different things for different researchers - matter in the climate change literature (Brooks, 2003; O'Brien et al., 2007). It is possible to identify two distinct framings of the climate change issue that emerge from different discourses on global environmental change what has been termed as outcome vulnerability and contextual vulnerability (O'Brien et al., 2007; Leichenko and O'Brien, 2008). Although difficult to be integrated into a single framework, these two approaches are complementary means by which it is possible to better understand the significance of climate and its relevance for society (O'Brien et al., 2007).

The widely cited definition of vulnerability is presented as being the degree to which a socio-economic and environmental system is likely to experience harm due to exposure to a risk, hazard, or changing conditions such as climate change (i.e. Liverman, 1990; Parry et al., 2007). In this sense, vulnerability is not only a result of how sensitive the system is to a hazard, but also how effectively its socio-economic and political attributes can act to reduce disturbances (Turner et al., 2003). The potential of a system to adjust to and limit risk is usually termed as its adaptive capacity (Smit et al., 2000; Smit and Wandel, 2006; Parry et al., 2007). This capacity can encompass a variety of adaptations. In this direction, vulnerability analysis can thus highlight the local level with its specific contexts, and thus examine adaptive capacity at large in a particular community or region, given that the stressors such as climate change will not occur in isolation from other stressors 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 different 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, what their roles and resources (Keskitalo, 2008).

3.1 *Projected impacts of climate change on the Northern coast*

3.1.1 Temperatures

To date, there are no specific assessments available that try to model and project climatic changes for the Northern coast of the State of São Paulo, although some research projects are under way and should present its results in the coming years. However, a number of studies have projected climate changes and possible impacts for the State of São Paulo 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 in the forthcoming decades due to global warming. In a downscaling exercise, Marengo (2007) took global climate models as references and projected an increase of 2° C up to 3° C in average temperature by 2100 for the Southeast region in Brazil. Although still surrounded by a considerable degree of uncertainty, these studies corroborate with the widespread global climate change projections that expect an increase in average temperatures with possible changes in the minimum and maximum temperatures (Marengo, 2007; Marengo et al., 2007b; Solomon et al., 2007).

3.1.2 Extreme events

There are also some few studies available that highlight a possible increase in the frequency and magnitude of extremes events within the course of this century in the region although they encompass high levels of scientific uncertainty (Salati et al., 2007). It is also important to stress that these results do not provide the high confidence that could support 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. On the other hand, the region can be already considered vulnerable to climate variability and extreme events such as storms that have been a major source of attention and concern for government authorities and the local population. Due to the process of urban growth and land use pattern that has been cited above – where some people (poor) were pushed into risk areas – the frequency and magnitude 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). 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 flooding and landslides in the Serra do Mar slopes, particularly among the poor groups.

3.1.3 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 (Muehe, 2006; Neves and Muehe, 2008). Some estimates suggest that the sea level has already risen 40cm in the last 100 years and is expected to raise more as projected by many scholars and the Intergovernmental Panel on Climate Change (IPCC, 2007)⁶. In the State of São Paulo, different parts 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 different research projects in the region (Souza, 2003; 2009; Borelli, 2006). 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, 2008).

Although SLR and coastal erosion are long-term natural processes, human activities combined with global changes in the climate system can amplify its pace and consequences as it has been outlined by different authors that have been analysing the 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 in the study area. Based on IPCC emission scenarios (B2 and A2), recent estimates that have been published indicated that material losses within Brazilian coastal zones could range between US\$ 75 billions and US\$ 115 billions. The cost of some basic adaptation measures that could limit losses and deaths in the long-term (15 in total) would be around US\$ 2 billions if implemented until 2050 (Margulis et al., 2010). Even though the figures concerning adaptations that would limit the impact of climate change on the coast of Brazil are still preliminary exercises that need further consideration and updates, it shows that the investment for planned adaptation is less than 3% of the total material loss projected. However, the municipalities of the Northern do not have the technical, financial and political capacity to undertake these measures without strong commitment and support from the government at the state and national levels.

⁶ These figures for Brazil have been collected through personal communication with Prof. Afrânio Mesquita (IO/USP).

3.2 *Socio-economic vulnerability and adaptive capacity of coastal cities to address climate risks*

3.2.1 Socio-economic vulnerability of coastal communities on the Northern coast of the State of São Paulo

Among the major socio-economic groups located on the cities that are part of the Northern coast of the State of São Paulo and that can be affected by climate variability and extremes, sea-level rise and future climate change in general are families that range from low-income to high-income households. The low-income groups are composed by small fishermen, micro-entrepreneurs, and people that work in the informal job market usually doing cleaning and housekeeping for the second residence houses and land owners. In general, they have small capital assets and live in informal settlements that are considered to be more exposed to climate events (SMA/CPLA, 2009).

The middle and high-income households are mainly composed by people that live in bigger urban centres and just go to the region during the weekends, holidays or summer time. They can also be permanent or contract workers that are living in the region due to the port activities and the emerging oil and gas industry that is bringing a number of infrastructure investments to the four cities with figures that can easily exceed billions of US dollars. These people possess bigger capital assets and live in concrete house structures and developed settlement areas which are located in places that are less vulnerable to flooding or landslides although there are some high-income residences that could be considered highly vulnerable to flooding and landslides under climate change projected impacts in the municipalities of Ubatuba and Ilhabela. However, most of losses and casualties reported so far in the region are mainly concentrated within those that belong to the low-income groups.

In this sense, previous analyses that consider the impacts of climate events in the region have been showing that the vulnerability of socio-economic groups to climate change, variability and sea-level rise vary disproportionately among them. In general, the better-off households have improved coping mechanisms than the other groups and therefore can be considered as being less vulnerable. 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 effectively to these events, particularly the intense 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.

Another issue that deserves to be considered is the socio-economic status of the region. Although the State of São Paulo ranks among the highest socio-economic indicators within the Brazilian context, 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, and homicides for instance. The way the region has developed – fast and without plan and control – has brought serious social and sustainability challenges. At the same time, the lack of adequate sanitation infrastructure brings various health problems for the population and degradation to the environment. Table 2 shows a summary of the sanitation situation in the four cities of the region.

Table 2 – Sanitation infrastructure

System status	Caraguatatuba		Ilhabela		Ubatuba		São Sebastião	
	Population (2007)	%	Population (2007)	%	Population (2007)	%	Population (2007)	%
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
Without project	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 SABESP (2008); SMA/CPLA (2009).

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. Although there are many facilities under construction, it is clearly not enough. It is also important to notice that many of these interventions are still not considering climate change in its projects. However, some studies are beginning to show that SLR might have an important impact on sanitation systems along the Brazilian coastline and there is widespread lack of awareness to this and other climate change issues in these coastal regions (i.e. Neves and Muehe, 2008; TCU, 2009).

3.2.2 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 and climate change issues is weak. However, the local governments of the four cities that compound the Northern coast of the State of São Paulo

have been trying to implement some adaptation strategies in order to minimise the adverse effects of climate risks on the coastal communities. These include information campaigns and raising awareness of those who live in high risk areas; relief assistance and evacuation; and resettlement of some vulnerable families to safer areas. Although these measures can generally reduce the vulnerability of some households to the undesirable impacts of climate variability and 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 and factors related to ongoing socio-economic change 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 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 could take place through changing management strategies. One example is the civil defence plan that the State of São Paulo have been implementing in partnership with local governments in municipalities that are considered to have more people living in risk areas. On the Northern coast, there has been implemented a preventive plan of civil defence (PPDC in Portuguese) that seeks to provide the municipal governments with the instruments and strategies to reduce the number of losses and casualties that result 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 urbanisation and the recognition that the governments in this area cannot solve 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.

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 zoning⁷. 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 State of São Paulo.

Table 3 – Possible local adaptive strategies

Response option	Possible measures
<i>Retreat (progressive abandonment of high risk and vulnerable areas)</i>	No development in vulnerable areas; Resettlement of households in vulnerable areas to safer

⁷ This responsibility is also shared with the state and national levels that are also in charge of coastal management and zoning.

	zones;
<i>Accommodation (sustainable use of the environment and continued occupancy and use of the vulnerable area through adaptive management)</i>	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 risky zones
<i>Protection (defence of vulnerable areas, population centres, economic activities and natural resources)</i>	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;
	Implementation of disaster risk reduction;
<i>Other proposed adaptive and capacity-enhancing strategies</i>	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;

It is important to notice that decisions and societal trends outside the region also have an impact on the vulnerability of the area. This study shows that the decision to build import roads and port facilities in the 1960s and 1970s have fostered the process of urbanisation of region in a way that the municipal government did not have the technical and political capacity to steer and control the development process causing many problems to the population and the environment. Today, a new cycle of major investments in the area to provide the necessary infrastructure for the emerging oil and gas industry are about to deepen social and environmental challenges, rising concerns in terms of the sustainability of the region in the future (Borelli, 2006; SMA/CPLA, 2009). Although the municipal governments in the region participate in the discussions with other public and private actors and these interventions encompass a number of other improvements and compensations for the cities involved, many of these facilities are being treated as issues of national sovereign and energy security by the national government counting with strong political support. In the same direction, they are considered significant for the economic development of the State of São Paulo by the state government, which also have major interests in the area including its important protected areas.

4 Conclusion

This study illustrates the large impact of socio-economic and political conditions and changes on the vulnerability and adaptive capacity of a particular region, namely the Northern coast

of the State of São Paulo, Brazil, in terms of its capacity to address the anticipated effects of climate change and variability. In particular, the degree to which the vulnerability and adaptive capacity of this region are dependent on decisions taken elsewhere, as well as the repercussions for public services, infrastructure and individual choices. The strong element of socio-economic change driven by 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 local and regional situations and capacities for adaptation.

In this sense, the study shows that climate change and variability will impact an area that already faces different patterns of vulnerability to both socio-economic and environmental change. This is what might loosely be termed ‘path dependency’ for development, where existing conditions and adaptation paths and priorities determine what can be done to reorganize change. Thus, 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 risky areas, excluded from the development benefits and exposed to climate change and variability. Although they are already facing the effects of climate variability, increased average temperatures, SLR and more intense and frequent rainfalls as a result of global climate change may have critical effects on these populations and their livelihoods that are already sensitive to multiple stressors.

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 that has been marked by different drivers of change. It will demand not only sound science-policy interaction, data and analyses, but also political-will and financial and technical resources that are not available for 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 frameworks available at the local level in this region do not address climate change adaptation specifically, but they provide interesting opportunities for reducing vulnerabilities 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 other ongoing developments and trends: in this perspective, climate change represents an added impact on already vulnerable communities. Studies such as the present one thus serve to indicate not only levels of vulnerability but also the particular points of vulnerability where external amelioration strategies could be directed bringing to light the relative importance of issues for the communities that are fundamental for policy making in regards to climate change.

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