CHAPTER 21

Toward sustainability of development in the southern coast of Brazil

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Abstract

The estuarine region of Patos Lagoon, in the southern coast of Brazil, has experienced a process of huge environmental changes, due to an intensive economic growth based on port and naval construction activities. Although such development may, on the one hand, produce wealth, employment, and revenue for the region, on the other, it might jeopardize the desired ecological sustainability in the estuary and its surroundings. Though it may be difficult to assess whether the transformation, the region has undergone, is ecologically sustainable, there are environmental impact indicators pointing to problems in reaching sustainability, suggesting the need for limits and guarantees of permanent resource input for its desired sustainable development. Therefore, a few management support tools have been recently created and tried in the region, as an attempt to establish an appropriate planning process for the occupation of its space and the balanced use of its natural resources. Those tools are able to lead to the desired sustainability in the development of the region.

Keywords: Patos Lagoon, estuarine regions, Pré-sal, Costa Sul Program, Rio Grande do Sul.

1 Introduction

1.1 The Estuarine region of Patos Lagoon

The estuarine region of Patos Lagoon, located in the southern Brazilian coast, may be considered as an environmental system with a high ecological, economic, and social importance. Patos Lagoon, in turn, is a coastal system of impressive
dimensions. Having an area of 9913.93 km$^2$ \cite{1}, it is classified as the largest coastal lagoon of the ‘choked’ type (with a restricted connection to the sea) across the globe \cite{2}. The estuarine region, approximately limited by coordinates 52°14’46” W 31°41’40”S and 51°58’24” W 32°11’59” S (Fig. 1) encompasses important urban centers of the Brazilian southern shore, such as the cities of Pelotas and Rio Grande, as well as a substantial pool of production, transformation, and business activities. In spatial terms, the estuary represents around 10% of the lagoon’s area. In ecological terms, it may be classified as a typical estuary of a transition system between ocean and continent, thus suffering the influence of processes, sources, and controls from both. It is of great use due to diversity and density in the water body itself and by the margins of the estuary of Patos Lagoon, which includes urban occupation, port and industrial activities, an important summer resort and tourist activity, environmental protected areas, artisanal and industrial fisheries, and coastal agriculture.

Recently, new discoveries of important oil and gas fields concentrated on the Exclusive Economic Zone in the southeast region of Brazil – a deep-ocean, subsalt formation known as Pré-sal \cite{3} – have generated a big thrust in the sector related to the exploration, refining, and transportation of those energy sources. Similarly, the new and important phase in Brazilian oil production has significantly stimulated the national shipbuilding sector, with ships for oil and gas exploration and transportation, and the development of port areas to provide logistic support to the endeavor. In the estuarine region of Patos Lagoon, such influence has caused intensive development, particularly in the area known as Low Estuary of Patos Lagoon, formed by the cities of Rio Grande and São José do Norte in the sector directly connected to the Atlantic Ocean, where the Port of Rio Grande is located. In this sector, the installation of an offshore naval construction pool has brought a sizeable enhancement in the local economy, and may generate considerable environmental impacts on estuarine ecosystems \cite{4}. There is no doubt that the region has grown through tax generation and employment and income opportunities \cite{5}. On the other hand, the sudden development in this area has raised instigating and challenging questions, such as: Is this new development cycle in the region sustainable? Can it ever be sustainable? What is the limit for such economic growth? What is sustainability after all? There are no ready and simple answers for these questions, but maybe a few indications of what they might be. To examine them, a few considerations are called for regarding environmental systems – such as the estuary of Patos Lagoon – and their environmental sustainability.

2 Environmental systems and sustainability

Environmental systems are entities or units integrated by components or processes with ecological, economic, and social characteristics. As every system, ecological systems have their own dynamics, established through the connections among its components (processes) and through importation and exportation of matter, energy, and information from within and without the system; thus, they establish
Figure 1: Estuarine region of Patos Lagoon.
an interaction with surrounding environmental systems. Also, as with other systems, environmental systems use and transform several forms of energy needed for their functioning, downgrading it through use, and exporting it outside the system as heat. The spent energy, which is finally lost through the system’s workings, needs to be replenished in order to guarantee the dynamics and the very existence of the system; hence, the need for an external (more usual) or internal (rarer) energy source. The estuaries, such as the Estuary of Patos Lagoon, are excellent examples of environmental systems with characteristic ecological (e.g. salt marshes, sea grass beds), economic (e.g. port and commercial activities), and social (e.g. fishermen community) components. Examples of energy sources that support the dynamics of estuarine systems are the input of nutrients and organic matter from the continental watershed [6] and the energy of waves and tides that invade the estuarine area, feeding processes as the mixture of waters, and suspension of nutrients and organic matter [7].

It may be said that an environmental system, such as the Estuary of Patos Lagoon, presents a state of ecological sustainability when its processes (its workability) and its components (its composition) are maintained along time and with the desired quality. Of course, for the continuity of its processes, the environmental system requires an energetic support from sources that may be external or internal to its boundaries. Such energy sources, on their turn, may have a renewable (e.g. tide energy, river water input) or nonrenewable (e.g. energy from oil and gas) character. The loss of sustainability in an environmental system may thus be due to a quantitative reason, as a loss or impairment in its elements or processes, or to a qualitative reason, represented by a loss of quality in those elements and processes.

Negative environmental impacts lead to a loss or decrease in ecological sustainability, affecting the system’s elements, processes, and quality, for they 1) reduce its productive ability, 2) reduce its quality (in air, water, soils, the biota, man-made structures, and quality of life), 3) reduce its scenic value (the beauty of the environment), and 4) reduce its biodiversity [8,9]. Besides the effects caused by negative environmental impacts, an environmental system may also have its sustainability affected when there is exhaustion or a decrease in the internal or external energy sources that provide support to all elements and processes that comprise it and guarantee its ecological, economic, and social dynamics.

3 Ecological sustainability in the estuarine region of Patos Lagoon

Can the estuarine region of Patos Lagoon be an ecologically sustainable system? The answer to this question is contingent on three fundamental aspects: the time scale in which it is considered, the maintenance or permanent substitution of the energy sources that support environmental resources and activities in the region, and the intensity of usage of such resources. The system may be considered sustainable for a short period of time (a few years) when its components and processes are kept basically constant. On the other hand, if the model of occupation
and resource usage is maintained, it is possible that it will not be sustainable on a longer time period (a few decades). It is also possible that the estuary may show partial sustainability. It may be economic, but not ecological, or maybe ecological, but not social. It is certain that the ideal would be to achieve integrated environmental sustainability (ecological, economic, and social) for a longer period of time. Regarding the energy sources required to maintain the processes working and guarantee the quantity and quality of environmental components, it may be assumed that they are prone to possible changes, variations, and exhaustion capable of threatening the estuary’s sustainability. Support energies are contingent on natural patterns, and may be altered, e.g. by global climate changes such as those we currently face [10], and on the input of nonrenewable energy forms, as oil- and gas-based ones, which may depend on economic and political-administrative decisions [11]. It must also be considered that the ability of systems to maintain their composition and processes (their dynamics) sustainable is directly dependent on the intensity in the human usage of their natural resources.

It may be now said that, based on the likely negative environmental impacts caused by the various forms of ecosystem use and occupation in the estuarine region, there are indicators of loss of its environmental sustainability. An important indicator is the gradual loss in the productive capacity of some of its important environments and related activities. The small-scale fishery in the inner estuary and the adjacent ocean has shown a yield decrease, notably starting in 1970s [12], thus causing increasing economic and social instability for a high number of families that directly depend on the activity. Similarly, the decrease in the estuarine fishery indirectly affects several activities that take part in the productive chain, thus affecting the performance of the regional economy [13]. It is possible that, as with the fishery yield, there may also be a reduction in the productive capacity of environments comprising the margins of the estuarine region, where agriculture focused on the production of fruit and vegetables takes place. Intensively used soils may have a reduced productive capacity, demanding an increasing use of chemical fertilizers [14]. However, there is no conclusive information on such possibility in the region.

Further indicators of the likely loss of sustainability in the estuarine system are related to the environmental quality of its various components. For example, the region has seen frequent contamination problems, with a decrease in water quality [15] and loss of air quality due to the occurrence of multiple air emissions from port activities and the industrial park concentrated in the city of Rio Grande [16].

Even obeying the legal regulations, the enhancement in port and industrial activity in the city is followed by a gradual increase in aerial and aquatic contamination; also, they require more space, services, and infrastructure, thus increasing the pressure on the pool of natural resources such as air, water, fishery resources, biodiversity, and urban environmental quality. Population growth, stimulated by new investments, leads to an increase in the volume of urban traffic, including buses and cargo in the downtown area. This reduces air quality and increases sound pollution and discomfort in the urban area. The city is quickly verticalized, provoking microclimatic changes and reducing the insolation of dwellings and
streets. Urban voids have been filled, and the city is gradually losing sight of its waters, the prevailing element in the urban landscape. Such changes, which jeopardize the quality of life for the population, constitute externalities inherent to the development process now in course [17].

The loss of scenic quality (the landscape’s beauty) may also be considered as an indicator of environmental impacts that would lead to reduction in sustainability. In that sense, the depreciation found in scenic quality is regretful, particularly in the margins of the estuary where there are appropriations of public areas by low-income populations, where solid waste is commonly used as landfill to receive illegal constructions, as well as upper-class condominiums, which prevent public access to the waters [18]. Those are situations that contrast with estuarine areas with little or no human occupation, where several of its various environments still maintain an almost pristine state [19].

The loss of environmental beauty, though it may be considered as a highly subjective aspect, may certainly affect the capacity of the area as a resource for tourism and leisure activities, with undeniable economic effects. It undoubtedly is another important life-quality indicator for the local community. Finally, the loss of biodiversity in the region of the estuary of Patos Lagoon and its surroundings may be seen as an indicator of its environmental sustainability. Though there is no conclusive information on an eventual reduction in biodiversity, there are a few worrying indications. For example, a fishery represented in the past by a group of species explored at different time intervals along the year and with the use of distinct fishing gear [20] tends to focus today on the pink shrimp (Farfantepenaues paulensis) and mullet (Mugil spp) fisheries. Similarly, there is a gradual biodiversity loss in estuarine ecosystems, particularly related to the development of the port area and urban expansion in recent decades [21]. The silvicultural activity found in the region, through the commercial exploration of pine species (among others), has also led to environmental simplification, by replacing coastal field ecosystems having a substantial species variety with monospecific farming [22, 23].

4 Seeking sustainability in development

When the question is how to maintain the ecological sustainability in the development of the estuarine region of Patos Lagoon, there is no single or trivial answer. However, a few premises may be used at an attempt to answer it. The first one relates to the maintenance of the productive capacity of the estuary. It seems logical that there must be limits regarding such productive capacity. In other words, those are needed limits related to the mode and intensity of use and occupation of estuarine environmental resources. The other basic premise relates to the energy sources that provide support to the natural or human productive activities in the estuary. The sustainability in the development of the region is only possible when the energy sources – renewable and nonrenewable, external and internal – required for the productive processes are guaranteed through time. Those sources and processes allow the organized permanence of the estuarine components, such as its ecosystems, fishery stocks, human population, and the structures built to support
production, transportation, housing, leisure, among other activities. Therefore, when the question deals with sustainability and development, there seem to be two keywords: limits and support. In order to guarantee a proper limit to the use and occupation of the ecosystems in the estuarine area of Patos Lagoon and guarantee support (under several energy forms) to maintain the environmental services provided by the system as well as economic and social processes of interest to the community, organized planning and management actions are necessary. These are not trivial actions. A complex, highly used, and occupied system as the estuary requires equally complex planning, besides permanently seeking the establishment of management processes that are agile, participatory, adaptive to eventual new needs, and efficient [24]. They are actions that require the integration among the economic sectors and main stakeholders involved, and require an appropriate framework, that might be technically structured through planning and management support tools [25]. Those tools must necessarily include the ecological, economic, and social dimensions of management.

4.1 Costa Sul Program

The main support tools for environmental planning and management in the estuary of Patos Lagoon were produced during Costa Sul Program. The program – officially entitled Basis for Sustainable Development in the Estuary of Patos Lagoon – had as its central and long-term objective ‘the establishment of basic conditions to enable a local social and economic development process in the estuary of Patos Lagoon toward social, economic, ecological, spatial, and cultural sustainability’ [18,26]. Financed by the Inter-American Development Bank (IDB), the program was proposed through cooperation between the Federal University of Rio Grande (FURG) and the local government of the city of Rio Grande. It was developed between the years of 2005 and 2007. Conceived as a multidisciplinary and multi-institutional program, Costa Sul instituted platforms for the establishment of basic conditions for environmental management in the region, focusing its action area in the low estuary of Patos Lagoon – the region comprehended by the cities of Rio Grande and São José do Norte. The program was structured along four main threads, including 1) strengthening of institutional capacities for environmental management, 2) maintenance of sustainable traditional economic activities, generation of new employment and income opportunities for small coastal communities, 3) recovery and conservation of habitats and environmental resources, and 4) support for the development of human resources with training in environmental management [19].

An analysis of the products generated by Costa Sul shows, among others, tools that once appropriately executed, may provide the necessary support to planning and management actions toward sustainability in the development of the region. The tools, developed with the technical support of the university, have been adopted by the Municipal Environmental Departments in the cities of Rio Grande and São José do Norte. The territorial planning developed by the program attempted to have a participatory character and considered directives from the practices of
regional zoning [27], strategic planning [28], and the making of future scenarios [29]. The process of building a territorial planning proposal was developed through workshops with the presence of several stakeholders from the region, representatives from government sectors, university, local community, and nongovernmental organizations.

Initially, working with the ultimate information for the city of Rio Grande and collecting a large amount of environmental information produced by the university in the last decade [30], a few products were created, highlighting the ecological-economic zoning of the city. The zoning methodology followed directives established by the National Coastal Management Plan (PNGC), which proposes the institutional frameworks and actions for integrated marine and coastal management in Brazil, Presidência da República [31]. On the other hand, it attempted to include the local government. An interesting, intermediate product from the construction of the zoning plan was the creation of a map of sectorial interests, started during a workshop with government representatives from several sectors of the local administration. Sectors as fishery, industry, agriculture, environment, tourism, transportation, and culture indicated the areas with the highest interest for land use and occupation in the city, seeking its development under the governmental view. In a second meeting, the previously generated map underwent criticism and adjustments from representatives of the local community, leading to a new version that best reflects the social interest (Fig. 2). As it integrates such goals, the map of multiple interests generates a new map of conflict areas and intensities, which is of great value for local managers. This spatial conflict map may be seen in Fig. 3. It shows places with different conflict intensities through a subjective qualitative classification, but reflecting the consensus reached among the participants in the workshops. The map suggests that there are some types of conflict of use or interest all over the city territory, but mainly concentrated along the channel connecting the ocean and Patos Lagoon, where a heavy port and industrial activity leads to confrontation of interests with other actual or potential activities. Along the oceanic coastline and the inner environs of the estuary (bays and shallower inner inlets), the conflict level is rated as intermediate, being highly related to the activities of environmental conservation, tourism, small-scale fishery, and coastal agriculture. In the inner portion of the municipal district, significant areas of intermediate conflict are associated with coastal fields and wetlands, with interests for rice harvesting, cattle farming, forestry for timber production, and environmental conservation. Having information about the trends for conflict spots and intensities, the municipal environmental manager or policymaker may establish some reactive or proactive directives, priorities, and actions relative to coastal management in the city. Being based on a georeferenced information system (GIS), integrating detailed information from several sources, the produced zoning plan had a level of spatial detail that was likely to be excessive for managers to use and of difficult application in practical purposes. That led information to be fully included, but a final map with a higher aggregation level, highlighting the main ecosystems in the area, was created with the expectation of providing a user friendly tool for the environmental planner or manager (Fig. 4). Since the underlying idea is the
search for sustainability in development, the produced zoning plan attempted to classify city areas according to levels indicated for use and occupation. Thus, the zoning plan for the continental area of the city presents a division in zones for preservation (zones of maximum environmental protection), conservation (zones
Figure 3: Levels of potential conflicts for the municipality of Rio Grande.
Figure 4: Ecological and Economic Zoning for the Municipality of Rio Grande. Classes 1 to 'special class' are classes for use restrictions defined by (CONAMA, 2005); APA: Environmental Protection Area; APP: Permanent Protection Area; AP’s: Protection Areas; ESEC: Ecological Station.
of restricted use), and development (zones of planned use). In the aquatic portion of the city, the zoning plan proposes a use-intensity classification based on maximum levels of potentially contaminant chemical substances, according to water quality standards defined by the National Environmental Council [32]. In general, the oceanic and estuarine coastlines, with the occurrence of beaches, dunes, and salt marshes, as well as interior wetlands, are classified as Preservation Zones. On the low-altitude coastal fields, the Conservation Zones prevail, whereas the Development Zones are found in higher (and drier) coastal fields. In the aquatic portion, areas with the highest use restrictions are mainly represented by shallow, protected estuarine coves, characterized as important ecosystems for the reproduction, growth, and foraging of several species (salt marshes, sea grass beds, and intertidal mudflats). The areas with lesser restrictions are those used for port and navigation activities. The ecological–economic zoning plan has also considered zones for environmental recovery. In the region, they are mainly represented by areas used in the past for timber production (pine stands) and areas with solid waste disposal, currently deactivated but still considered as an environmental liability.

Besides territorial planning actions in the low estuary, represented by the several maps that led to its ecological–economic zoning, Costa Sul Program produced another set of tools for management support toward sustainable development through the participatory making of environmental management plans. Those are comprehensive plans that structure, guide, and integrate environmental management in the low estuary, by making use of other tools that provide it with support (ecological–economic zoning, environmental information systems, environmental programs, such as environmental education, and environmental monitoring programs). The plans, though based on a large amount of scientific information and traditional community knowledge, have been elaborated through a framework and language to be used by local managers (http://www.costasul.furg.br/pt_br/no_visual.php?inc=planos.html). The first plan was elaborated for Marinheiros Island, the largest estuarine island in the region, which, due to its unique ecological, economic, and cultural importance Rebouças [33], has become an outstanding case for study and procedural development of management plans. Subsequent plans were created for the cities of Rio Grande and São José do Norte, covering the whole area of the low estuary.

The planning process involved a group of discussions in workshops with the participation of stakeholders from governmental and nongovernmental organizations and society. The discussion for the elaboration of the plan took place under a joint coordination by FURG and the Municipal Environmental Departments from the cities involved. It had the presence of the following sectors: cattle farming, fishery, forestry, agriculture, transportation, port, urban occupation, tourism, culture, and nature conservation.

The workshops adopted methodology that attempted to establish an environmental agenda, composed by actions seeking solutions for the main environmental problems in the region through the perception of the participants [34]. A simplified representation of the elaboration process for this agenda may be found in Fig. 5.
The sequence used may be followed through 1) identification of major problems, 2) establishment of goals relative to each problem, 3) necessary actions for each goal to be achieved, 4) classification of actions in distinct types (technical, administrative, legal, political), 5) definition of execution deadlines for actions (short, medium, and long term), 6) identification of individuals or institutions responsible for the execution and enforcement of the actions, and 7) definition of progress and success indicators for the proposed actions. Optionally, the procedure may also suggest the origin of resources necessary to finance the proposed actions. The basic structure of the management plans is represented in Table 1.

The environmental management plan elaborated for the city of Rio Grande was named Municipal Environmental Plan (PLAM) and has become a management support tool, mainly used within the Municipal Environmental Department of the city of Rio Grande. PLAM is composed of an environmental inventory and diagnosis, and integrates different tools, such as the ecological-economic zoning, the municipal system of environmental monitoring, the municipal environmental quality report, and the neighborhood impact study. The environmental programs composing PLAM include the 1) environmental control and licensing program, 2) environmental management and planning program, and 3) environmental education and social communication program.

Each program, on its turn, is organized through a set of subprograms, as shown in Table 1.

The institutional arrangement proposed for the implementation and execution of PLAM is composed by public and private institutions. The Municipal Environmental Departments are responsible for the coordination and execution of PLAM, having as a deliberative organism the Municipal Environmental Council (COMDEMA), which is constituted by representatives from the city government, nongovernmental organizations, and society representatives. Financial support for implementing PLAM comes from the Municipal Environmental Funds, which receive resources from licensing fees and environmental fines. Access to the fund is granted by COMDEMA to the Municipal Environmental Department.
Table 1: Basic structure for the Municipal Environmental Plan (PLAM).

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<td>Priorities, strategies and responsibilities. Functional structure and management plan</td>
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<td>Ecological environmental Zoning, environmental information system, environmental programs, environmental monitoring plan</td>
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All planning actions for the low estuary region and the elaboration and implementation of management tools are favored by the fact that the estuary of Patos Lagoon is one of the best-known coastal regions in Brazil. FURG has studied and accumulated a significant amount of information about this environment in the past four decades. Based on such data collection, Costa Sul Program started the structuring of a georeferenced, digital environmental information system about the region, designated as SIAM (Environmental Information System). SIAM is a continuously updated system and serves as support to the various actions required toward the desired environmental sustainability in the region. A representation of some of the themes comprising the information system may be seen in Table 2.

5 Final remarks

5.1 Will we ever achieve environmental sustainability in the estuarine region of Patos Lagoon?

In order to consider the possibility of achieving ecological sustainability in the development of the estuarine region of Patos Lagoon, a few considerations are needed on the appropriate use and application of the tools thus far developed. The first question to be considered is related to the doubt over the actual implementation and execution of the PLAM in the city of Rio Grande and its counterpart in the city of São José do Norte. Although there are recent initiatives on the part of the
local government, so far, PLAM has a managerial character, but no legal foundation; there is no municipal law to establish it as mandatory in governmental administrative actions. Without legal support, the plan depends on the political will of local managers, and may undergo low-priority periods with the government. Due to its considerable complexity and its multidisciplinary character, the execution of the plan often involves the joint work of several distinct governmental departments, such as tourism, housing, and environment; such requirement leads to restrictions on its appropriate operation. The sectorial actions are the ones with the most tradition with the local government. Integrated actions among government sectors are still difficult in the current conjuncture, as they demand an innovative way to establish the necessary governance to advance the programs. It would involve the establishment of a new culture of cooperation and integration within the government and among stakeholders; such culture has yet to be appropriately established in the region.

Another important issue regarding the search for sustainability in the development in the region is related to the establishment of a municipal environmental policy that considers the achievement of sustainability as its overarching goal. The cities in the low estuary (Rio Grande and São José do Norte), in spite of having recently developed the planning and management tools described earlier, have so far not been able to establish an environmental policy that defines structuring principles and directives for their development with sustainability. In the absence of a guiding policy, new projects and initiatives proposed by the government and society for the region are, as a rule, somewhat disarticulated, mainly attending to the interests of economic sectors. Such fact certainly hampers initiatives by local and state managers for a better ordering of territorial occupation and use on the basis of appropriate environmental criteria. As the region has experienced accelerated development based on substantial energy input, economic investments and human resources from other Brazilian regions and abroad, sustainability in the development that is being established certainly depends on statewide and nationwide policy that might guarantee the noted energy flow. Therefore, the equation involving

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sustainability in the region has elements related to local actions, but notably depends on a necessary harmonization of local policy with public policy from another sphere of government planning. The equation has no easy solution. However, it seems vital to integrate technical and political factors, as well as the participation of all stakeholders to achieve factual enhancement in the region.

Brazil undergoes a highly important phase for the environmental management of its coastline and national oceanic area. The recent exploration and production of oil and gas within its exclusive economic zone has generated considerable economic growth in coastal areas that provide support to such an activity. Rio Grande and the estuarine regions where it is situated make for a clear example of such effect of development that may occur not only in a fast but also disordered and unsustainable way. Therefore, within such a context, possible lessons from efforts made for the establishment of an appropriate form of development in the region may be of great value for many other coastal cities facing a similar situation. It is a case that may generate important lessons to be appropriated by statewide and nationwide government programs of coastal and ocean management in Brazil; a case that demonstrates problems, but offers a great opportunity to establish an experience defining limits for usage, energetic support, and quality of life for its community.

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References

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