HOW EFFECTIVE ARE THE ENVIRONMENTAL-PLANNING TOOLS TOWARDS THE URBANIZATION PROCESS OF JUQUERIQUERÊ RIVER BASIN IN CARAGUATATUBA, SP?

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Abstract

In the beginning of this study, it was possible to comprehend the urban expansion of Juqueriquerê River Basin in Caraguatatuba, Northern Coastline of São Paulo State, Brazil, from 1986 to 2010. Remote sensing techniques were used to obtain information about the urbanization process in a multi-temporal analysis. In this period, mainly in this area, the urban development scenery completely changed because of

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the governmental project called Pre-Salt, which provided massive investments into gas exploration. This basin was previously vulnerable to irregular housing and flooding. However, some technical components, such as local outcomes of the environmental licensing process at the state or national level, were not considered. Thus, the political and normative components were not in the scope of public hearings. The purpose of this study was to verify the urbanization process, which occurred in the expansion area, and which determined whether this technical component should have been considered during the licensing process of the megaprojects for the effectiveness of environmental-planning tools.

Keywords: Land use; Urban expansion; Environmental licensing; Technical and political components; Decision arena actors.

QUAL É A EFICÁCIA DAS FERRAMENTAS DE PLANEJAMENTO AMBIENTAIS NO PROCESSO DE URBANIZAÇÃO DA BACIA DO RIO JUQUERIQUERÊ, EM CARAGUATATUBA, SP?

Resumo

Neste estudo, é possível compreender sobre a expansão urbana na Bacia do Rio Juqueriquerê, em Caraguatatuba, Litoral Norte do Estado de São Paulo, Brasil, entre 1986 e 2010.Para isso, técnicas de sensoriamento remoto foram utilizadas para obter informações sobre o processo de urbanização em uma análise multitemporal. Neste período, o cenário do desenvolvimento urbano, principalmente nesta área, mudou completamente por causa dos investimentos maciços na exploração de gás do projeto governamental chamado Pré-Sal. Esta bacia já é vulnerável à moradia irregular e inundações. No entanto, alguns componentes técnicos não foram considerados como produtos locais no processo de licenciamento ambiental, mas sim de níveis estaduais ou nacionais. Assim, os componentes políticos e normativos não estavam no escopo das audiências públicas.O objetivo deste estudo foi verificar o processo de urbanização que já ocorreu na área de expansão e determinar se este componente técnico deveria ter sido considerado no processo de licenciamento dos megaprojetos para a eficácia das ferramentas de planejamento ambiental.

Palavras-chave: Uso da terra; Expansão urbana; Licenciamento ambiental; Componentes técnicos e políticos; Atores da arena de decisão.

Introduction

According to the UNFPA (United Nations Population Fund) (2010), 50% of the world population lives in urban areas: the total is 75% in the most developed regions and 45% in less developed regions. In Brazil, the urban population was approximately 35% in 1950 and 84% in 2010 (IBGE, 2011). Deak (1999) affirms that in this period, Brazil changed from an agricultural country to a virtually urbanized country, and its urban population has increased six-fold. A fast population growth constitutes a major problem for urban sprawl management.

The end of the 20th century was remarkable for the acceleration of the urbanization process in Brazil, particularly in the State of São Paulo. The consequences of this process include the development of metropolitan regions; the verticalization and growth of the previously urbanized areas; and the urban expansion of the peripheral areas.

Power et al. (2008) state that, in urbanized areas, significant changes occur in the local natural resources regarding their ecosystem stability and in the indirectly affected areas. The urbanization process is responsible for the modification of rural areas because of the population growth and infrastructural requirements (PALEN, 1975). The low-income groups (exemplified by the auto construction and occupation of irregular lots) may have different spatial dispersion from the medium and high-income groups (exemplified by the construction of condos in larger areas).

Environmental vulnerability awareness is one of the main decision-making tools for developing sustainable planning (ROSSINE et al, 2002). However, in developing countries, the institutionalization of environmental tools has not promoted urban planning and disregards risky urbanism (SILVA; TRAVASSOS, 2008), which is characterized by irregular housing, floods, debris flow, water pollution, river silting, illegal sewage flow and hydro transmission diseases (ALVES, 2006; PEREIRA; SILVA, 2011), which indicates a social and environmental vulnerability (TORRES et al., 2007).

When the urbanization process is not truly organized by the State, because of economic interests, there is no concretization of what has been planned (FERREIRA, 2010), which may cause a social marginalization because the population requirements may not be considered a priority. Thus, it will not be possible to generate feasible conditions to deliberate and construct collective political actions for the welfare of the population (SELLER, 2014).

Salinas Chaves (1998) states that to have social adaptation, we depend on the adequacy of the decision-making process towards social equality, population growth balance and available natural resources. This decision-making process should be based on the agreement among stakeholders about the role of environmental licensing to avoid confusion about the expectation regarding the management tool (FEITAL et al., 2014). Decisions should be supported by technical elements because political and normative questions may not be answered using environmental-management tools (BALLESTEROS; BRONDÍZIO, 2013).

The characterization of different urban sceneries and the ecosystem vulnerability are technical elements that may be unavailable or uncertain for the decision-making process. In these situations, mathematical and computational methods have been widely applied, where hypotheses are made, and the predictions are simulated under different circumstances (BOULOMYTIS, 2011).

Urban modeling

In general, urban modeling includes new methods of expansion, such as the urban sprawl, but presents problems concerning the unawareness of physical and social-economic features, which may contribute to certain urban patterns and dynamics.

For Peng et. al (2007), a reliable source of this information is the remote sensing data, which allow for the continuous feedback and validation of urban models. Remote sensing techniques and GIS platforms have been very useful in urban area mapping, urban expansion and land use modeling. These techniques provide a flexible environment to store, process and analyze digital data from different sources; thus, updated spatial data may be obtained and detailed with high temporal frequency in addition to historical series. These data introduce a spatial and temporal vision of the urban growth and allow the provision of information about this environment, such as land use and infra-structure. The GIS environment may provide an effective platform to integrate different data models from several sources, such as census data to evaluate the urban environment quality level (GAVLAK, PRADO, 2013; LI; WENG, 2007).

Sparovek and Costa (2006) studied the interference of urban evolution on the quantity, quality and distribution of vegetation cover by analyzing the occupation dynamics and evolution of the urban sprawl in Piracicaba. The study was conducted using aerial photographs and GIS in five different dates during 1940-2000. In the vegetation survey, they verified that major portions of vegetation cover were found in the surroundings of the urban area and highlighted the necessity of knowing and planning peri-urban areas before these areas are modified by urban structures.

In a study of Quevedo Neto and Lombardo (2006), the authors emphasize that the dynamics of the urban-rural transition area occurs regarding the pressure suffered by the urban environment, which stimulates the real estate speculation. This pressure results in the modification of the environment, which is then characterized by a different land use mosaic. Thus, conflicts, which should be notably well-known, emerge for the constitution of a data base, which may allow urban planning and the application of public policies.

With the advance of new sensor development, there was an improvement of the spatial, radiometric, spectral and temporal resolution data. For instance, World View 3 imagery has a 30-cm spatial resolution and 17 multispectral bands. Thus, new possibilities for the use of orbital images began to be applied in urban studies. Thoroughly, new methods must be obtained to improve the data processing (MAKTAV et al., 2005), such as the automatization in the process of data interpretation, so that a large amount of information may be systematically and objectively produced.

The traditional systems of automatic classification are based on the spectral information of the considered pixel in a single level of information. Similar to the object-based systems of classification, the intelligent systems of classification allow the consideration of other attributes in addition to the spectral ones to describe the classes such as context, shape and texture. Therefore, this type of approach becomes similar to a human cognitive system in a visual interpretation classification. The advantage is to standardize the elements to be considered, reduce the subjectivity and increase the process speed, in addition to providing the possibility of reproducing the technique in other areas using different interpreters (LANG; BLASCHKE, 2003).

Several studies show the provision of better results in image classifications of urban studies by comparing the object-based approach with the traditional pixel-based methods (ALVES; FLORENZANO; PEREIRA, 2010; ANTUNES; CORTESE, 2007;YAN et al., 2006).

Environmental Assessment Tools

The basic requirements for the Environmental Impact Assessment (EIA) were regulated in Brazil in 1986 through Resolution 001 of the National Environment Council. The Environmental License system was introduced by Resolution 006 in 1986 and updated by Resolution 237 in 1997. Based on the effect of an enterprise, an EIA is required to inspect the local environmental vulnerability and the technical alternatives to minimize these effects.

In 2004, the Government of Sao Paulo regulated the first environmental zoning in a regional scale, which is called Ecological-Economic Zoning (EEZ). It is a helpful tool for the environmental license process because it establishes a specific land use for each area according to its natural resources.

The City Master Plan is a basic tool for municipal land use policy, which details the land use and possible activities to be developed in each zone. It must be according to the EEZ in the legal environmental process of the municipal and state hierarchy.

Although municipalities can be effective units to implement these environmental management tools, within a limited scale to comprehend the environmental issues (BRAND; THOMAS, 2005), the Strategic Environmental Assessment (SEA) can offer a priority scope in the decision-making process to achieve a sustainable development. The SEA may contribute in the land use management and distinction of integration features considering the environmental quality increase. The development proposal analysis in other scales is not limited by the specific project level (BOULOMYTIS; FABBRO NETO, 2011). The concept of the SEA is defined as:

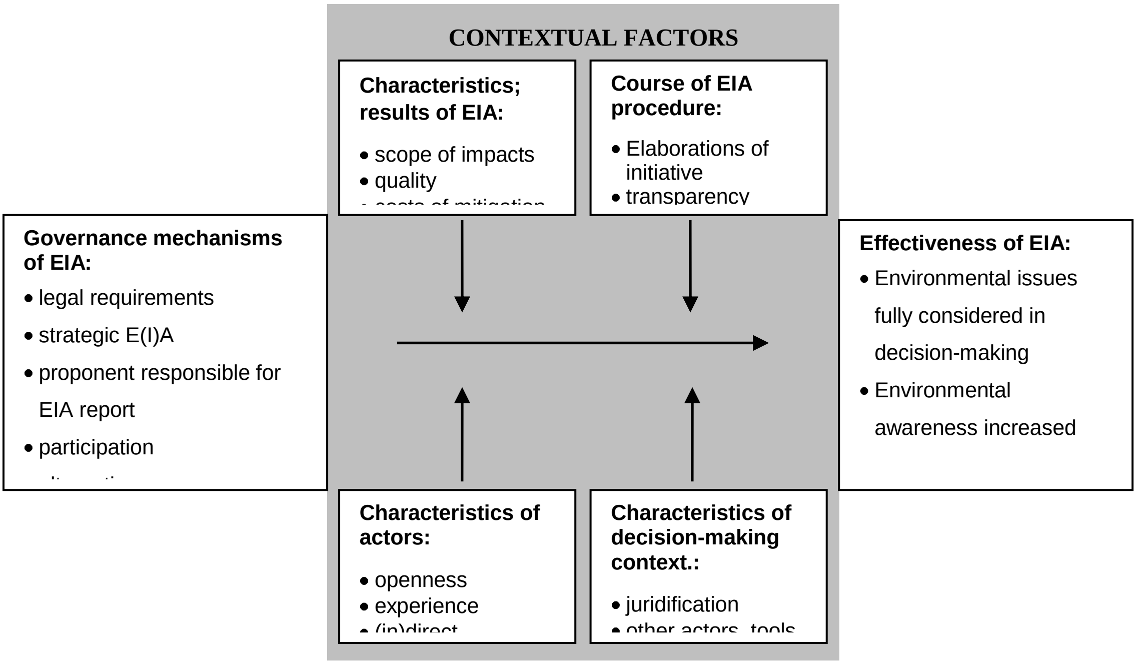
> [...]a result of the recognition that project-level Environmental Assessment (EA) processes typically occurred too late in project life cycles to be fully effective. In particular, there was an acknowledgement that individual projects were often initiated as components of larger policies and plans (MULVIHILL; WINFIELD; ETCHEVERRY, 2013).

The EIA effectiveness is based on the level of the goals to be achieved (ARTS et al, 2012), which includes the incorporation of environmental considerations in the decision-making process and the development of environmental awareness among arena actors (ARTS et al, 2012; FEITAL et al., 2014; THERIVEL, MINAS, 2002). Arts et al. (2012) established a conceptual model, where effectiveness is connected with the existing governance mechanisms and contextual elements (Figure 1).

In 2010, the government of São Paulo published the Strategic Environmental Assessment of Portuary, Industrial, Naval and Offshore dimension (SEA PINO), where the petrol exploration pressures were considered over the cities affected by Pre-Salt. The UTGCA (Monteiro Lobato Gas Treatment Unit of Caraguatatuba) EIA was analyzed, and the environmental license process approved the deep petrol reserve dig in 2011. Some of its elements predicted the land use by comparing the SEA and EIA with the City Master Plan (BOULOMYTIS; FABBRO NETO, 2011).

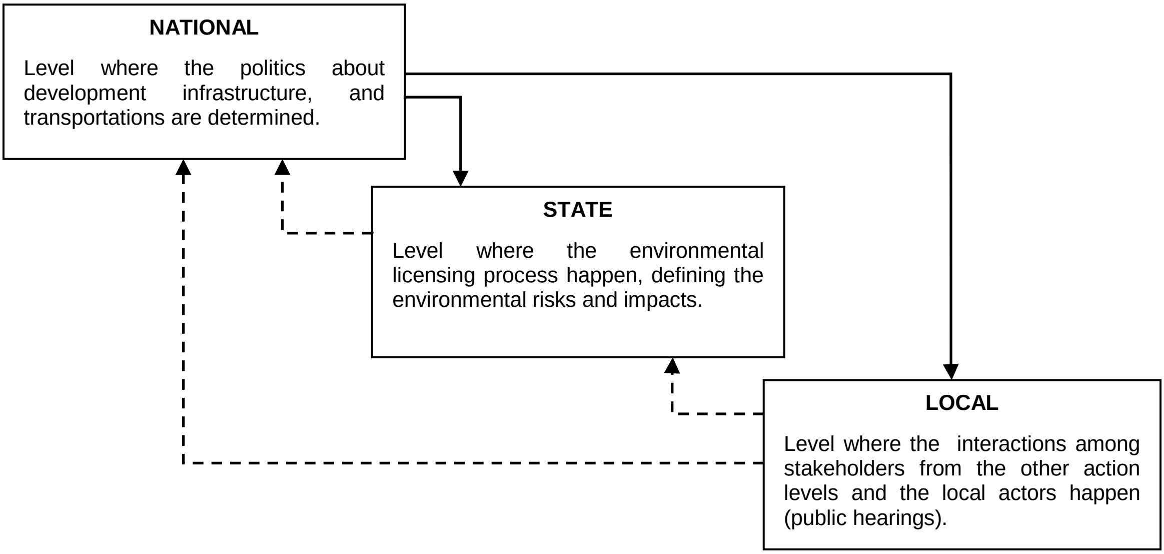
Feital et al. (2014) stated that the decision-making process of São Sebastião Port expansion was formed based on different action situation levels (Figure 2).

Figure 1: Relationship between governance mechanisms, contextual elements and EIA effectiveness



Source: Arts et al. (2012).

Figure 2: Different action situation levels of the decision-making process about the São Sebastião Port expansion



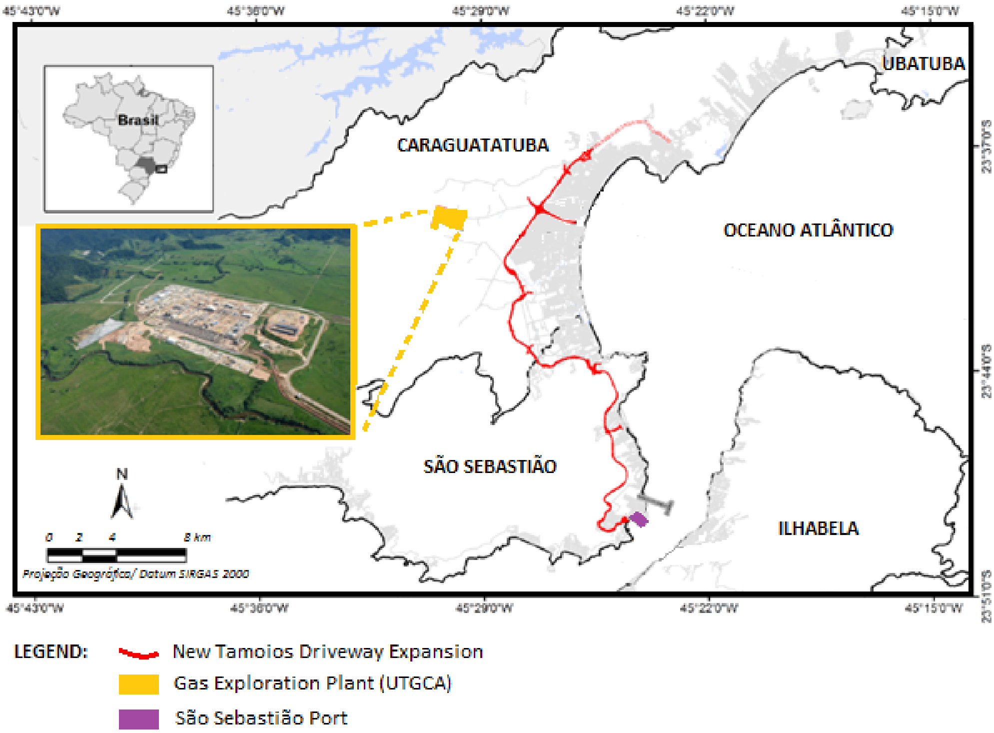
Source: Feital et al. (2012).

In their study, an Institutional Analysis and Development (IAD) framework was produced per action situation level that composed the decision arena studied. Then, it was possible to analyze the local situation, essential components and relationship among the levels.

Expansion Area Characterization

On the northern coastline of São Paulo, several megaprojects have been recently established for petrol exploration and logistic infrastructure, including the expansion of São Sebastião Port and Tamoios driveway complex. Among these projects, the plant of UTGCA, for gas exploration, was installed in the plains of Juqueriquerê River Basin in Caraguatatuba, SP (Figure 3).

Figure 3: Location of the study area and some megaprojects of the Northern Coastline of São Paulo



Source: Adapted from Teixeira et al. (2012).

Juqueriquerê River Basin is the major river basin in the Northern Coastline of São Paulo State, Brazil, with 419.80 sq-km. It is divided into two municipalities: 341.60 sq-km in Caraguatatuba and 78.20 sq-km in São Sebastião. Its waterway is a 4-km-long estuarine channel and is mostly used by small piers and docks. This basin is responsible for the major water discharge in the Northern Coastline of São Paulo State. It presents a significant potential for water contamination and environmental degradation because of the population growth, sewage collection efficiency, presence of marines in vulnerable areas, lack of normalization for the use of fluvial transportation and constructions in preservation areas.
According to Okida and Veneziani (1998), the fluvial and land use dynamics in the Juqueriquerê River Basin have been extensively

modified. The result is the flood occurrence because of the shallow water table level, impervious surfaces, and river-bottom silting. Thus, the fragility of the area is translated to a range of diverse issues: insufficient riparian forests along the watercourses, runoff increase because of rectified river courses and irregular housing along the watercourses and in the floodplains. The region is also characterized by the tourism potentiality and real estate speculation (MARANDOLA JR et al., 2013; GIGLIOTTI; SANTOS, 2013).

Urban Expansion Classification

In this article, urban modeling was provided by the urban expansion classification as an additional technical element to analyze the environmental impact and development of Juqueriquerê River Basin. Environmental assessment tools were used to analyze their correlation with the technical elements towards a sustainable development in the urbanization process.

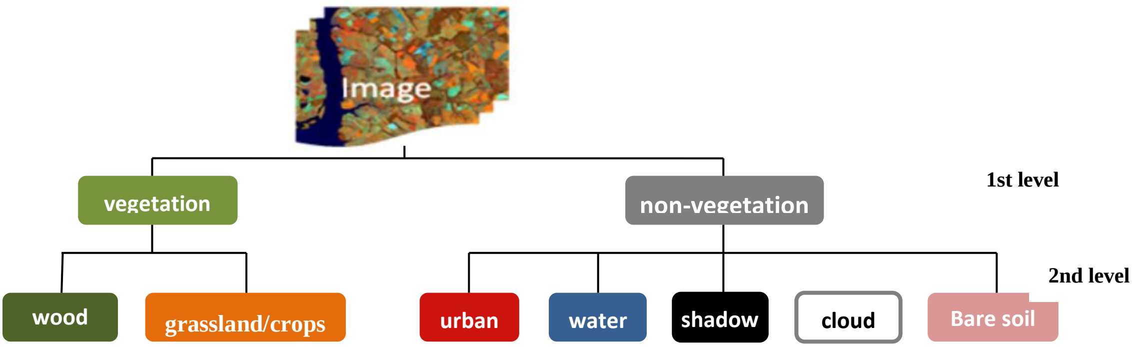
For the urban classification, the following satellite images were used in the study: TM-Landsat, orbit/point 218/76, bands 3, 4 and 5, acquired on September 16th, 1986 and May 15th, 2005; orthorectified GEOEYE, acquired on April 30th, 2010. The applied softwares were Definiens v.7 and SPRING v.5.1.7. The 1986 image classification was initially done, so only its increments were considered at the following classifications to minimize the data-processing time.

The thematic maps were elaborated from the classification of TM-Landsat images using the Definiens software with the Object-Based Image Analysis (OBIA). This method was based on two steps: segmentation and classification. In the first step, objects were created in different scales according to the shape, color and homogeneity, all of which were connected. In the second step, the objects became related by the definition of a class hierarchy (attribute heritage that describes a class) and semantic information (logical relationship structure among the classes).

Segmentation is a fundamental step in this process, which is responsible for generating homogeneous segments that represent the inherent dimensions of the objects in the images (BLASCHKE; HAY, 2002). In the Definiens software, segmentation is performed in two levels for a region-growing algorithm (multi-resolution segmentation), which is determined by a limier of similarity (the Weighted Average between color and shape) and a scale factor. The color parameter indicates the weight given to the spectral characteristics in detriment of the shape parameter. Then, the segments are subdivided into compactness/smoothness, with complementary concepts between each other, where a high value of compactness conducts to smaller and compact segments. These segments are opposite from the segments with more dendritic boundaries and boundaries of non-fringed edges, when the high value corresponds to their smoothness. The scale factor controls the maximum heterogeneity that is inherent to an object, which is determined by an interpreter; thus, a larger scale factor corresponds to larger generated segments (KRESSLER; STEINNOCHER, 2006). In this study, the parameters were: scale (10), shape (0.1) and compactness (0.5), which were empirically defined based on the knowledge of the interpreter regarding the specific targets and images.

From the definition of classes, the class hierarchy was elaborated and used in all different dates (Figure 4). In the first level of the 1986 image segmentation, the vegetation and non-vegetation areas the Normalized Difference Vegetation Index (NDVI) as a classification attribute. In the second level of segmentation, different classes were classified, where texture attributes were used to separate the urbanized areas from the bare-soil ones, and spectral attributes (average between bands 3 and 5) were used to separate the water and shadow classes. For the cloud separation of other classes, spectral attributes were used, which included negative values of NDVI and maximum value of brightness.

Figure 4: Class hierarchy used in the image classification process.



In the classification process, the highest level of pertinence of an object regarding a class is used by the fuzzy logic (CHUBEY;FRANKLIN; WULDER, 2006). In Definiens v.7, the fuzzy pertinence functions are elaborated by the selected attribute histograms. An object of a certain class can be qualified based on the level of pertinence, which is provided by imprecise limits. In addition to the spectral and texture attributes, relational attributes were used to consider identical classes on different dates, which include the object attributes, relationship among the classes, global relationship and logic operators (which may occur at an the same identical class hierarchy level, higher or lower ones). The group of attributes that describe each class is called the descriptor. To elaborate the descriptors, samples were collected.

The 2000 Landsat images were classified based on the obtained classification of the 1986 image for the urbanized area, where the increase in urbanization only occurred in that period. The same procedure was adopted for the 2005 image classification using the results of the 2000 image. To classify the 2010 high-resolution image, the same procedure was applied. OBIA techniques were notably useful for the classification of high-resolution imagery.

The image classification was validated by collecting random and stratified groups of samples based on the visual interpretation of the images, the interpreter's knowledge of the area, and the pre-existing topographic maps and charts.

Governance Mechanisms and Contextual Factors

This study analyzed the governance mechanisms and contextual factors based on the methodology proposed by Arts et al. (2012) and the analysis of technical elements, which was verified using urban modeling and the results of Boulomytis and Fabbro Neto (2011), Teixeira et al. (2012) and Feital et al. (2014).

Boulomytis and Fabbro Neto (2011) examined the relationship among the environmental-planning tools (EIA, SEA/PINO, City Master Plan and the EEZ) for the megaprojects in the scope of Juqueriquerê River Basin. Initially, the SEA PINO social and economic effects were compared to the land use prediction of the EIA. Then, the analyzed topics were combined with different guidelines in the City Master Plan and EEZ.

Teixeira et al. (2012) approached the megaprojects in their total range. This work studied the relationship between the co-located facility megaprojects and the social and environmental changes in the region with high ecological significance and major social problems. The methodology was based on the analysis of 13 environmental impact studies of development projects in the Northern Coastline of São Paulo. Three impact-assessing methods were used as a comprehensive approach. In total, 7 environmental, social and economic indicators were analyzed to identify and assess the cumulative effects of the projects.

Feital et al. (2014) studied the environmental-planning tools in the scale of São Sebastião Port Expansion, which is in the indirectly affected area of Juqueriquerê River Basin. They showed different action levels related to the decision arena about São Sebastião Port extension, the main components of each level, and the feedback relations among them. The study was conducted using the IAD framework, which identified the network of action-situations (at national, regional and local scales), their components and connections.

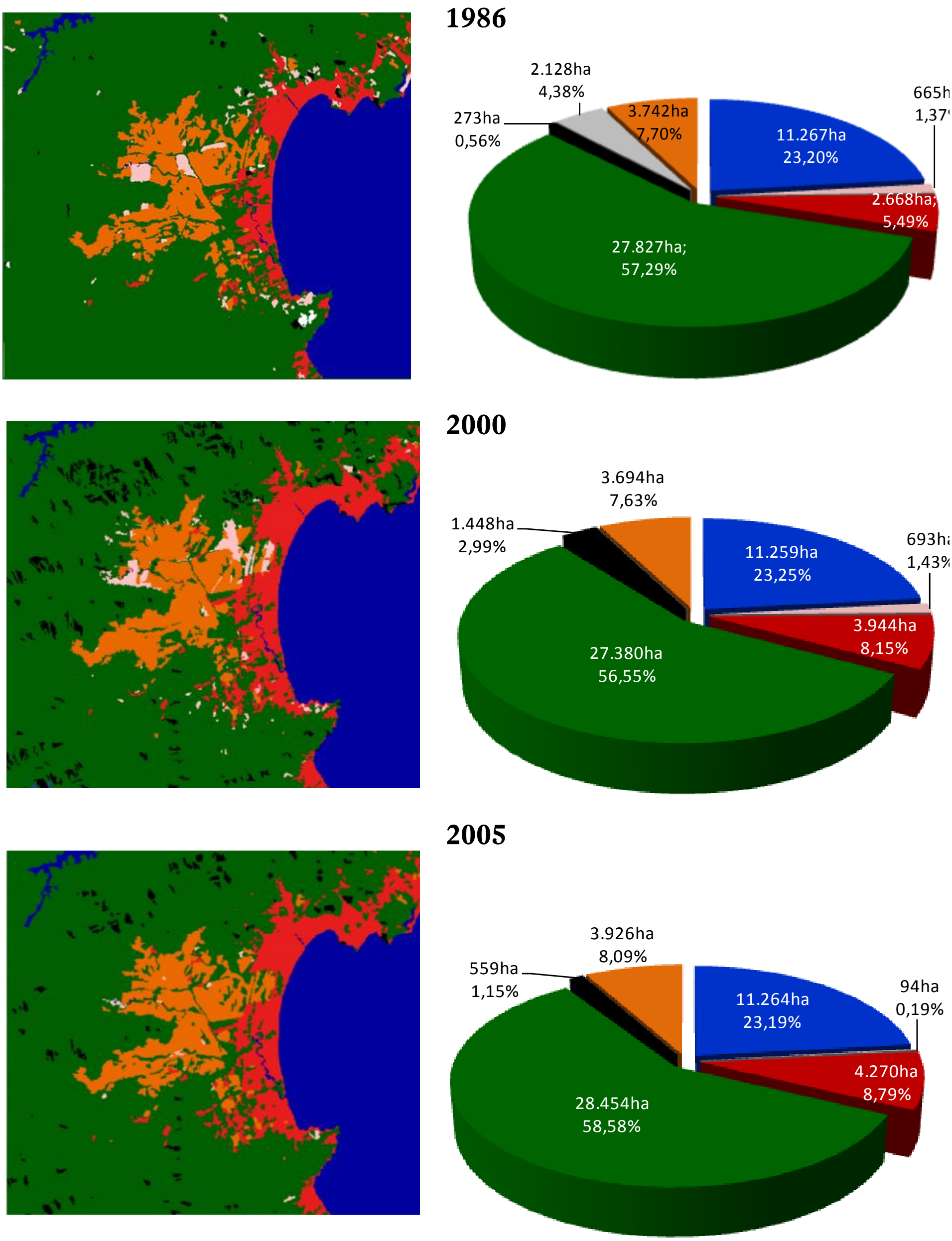
Results and Discussion

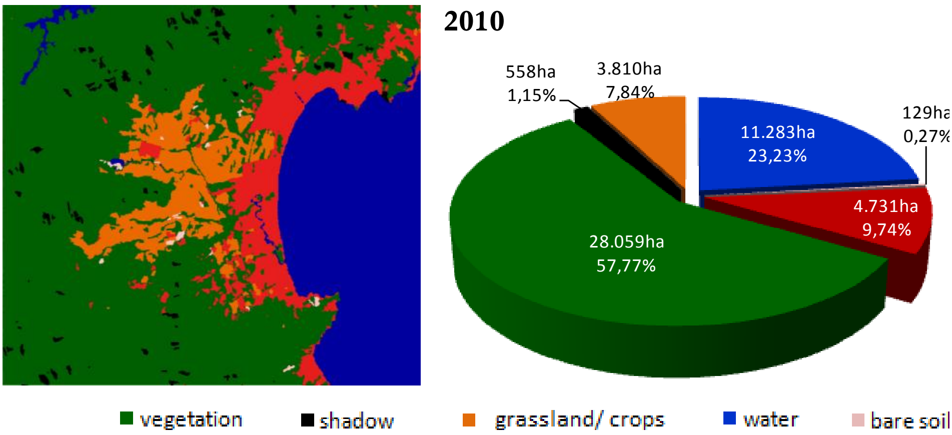
In the object-based classification, it was possible to verify that there was confusion among the classes that represented some urbanized and bare-soil areas, mainly in the mountainous region (commission errors). The commission errors of urban classes occurred in bare-soil areas because of the transition use of new lots and industrial areas under implantation. The classification results of their Kappa Index were reasonable for the 1986 image (k=0.78) and excellent for the 2000 (k=0.81) and 2005 (k=0.84) images (CONGALTON; GREEN, 1998). Thematic maps were obtained from the classification of the 1986, 2000, 2005 and 2010 images (Figure 5).

Urban expansion was observed in the decrease of the increase rate in the urban areas of all studied periods: 48% (1986 to 2000), 8.25% (2000 to 2005) and 10.80% (2005 to 2010). The relative growth rate of each period was 3.42% (1986 to 2000), 1.65% (2000 to 2005) and 2.16% (2005 to 2010), which shows that urban expansion mostly occurs in the first and last periods. There was a dispersion of urban areas with isolated agglomerations in 2010 over the grasslands and crops. A successive increase in urban area occurred down Juqueriquerê River from 1986 to 2010. In the last period, small portions of remaining vegetation were drastically reduced and replaced by urbanized areas. In this period, megaprojects started being developed in the area, which confirms the population growth and increasing necessity of infrastructure adaptation.

The multi-temporal analysis of land use in this study using urban modeling and geoprocessing techniques proves the social and economic effects in the expansion area. However, the EIA did not follow the SEA PINO guidelines and only detected the positive effects for social and economic issues. The impact assessment classified the effects on the biota and physical environment as local effects and the effects on the social and economic environment as regional effects (BOULOMYTIS; FABBRO NETO, 2011).

Figure 5: Thematic maps and classification areas of the 1986, 2000, 2005 and 2010 images





The City Master Plan of Caraguatatuba has been molded to implement UTGCA and did not follow the land use guidelines proposed by the EZZ. Indeed, the City Master Plan considers the Juqueriquerê River basin appropriate for urban expansion, which supports the SEA PINO and EIS perspectives for multiple land uses, mostly industrial and logistic. The municipal zone proposal diverges from the EEZ, which considers the Juqueriquerê River basin appropriate for agricultural uses. However, it is implied that in case the EEZ is changed, the City Master Plan, which has been approved by the local municipality, can expand the Juqueriquerê River basin according to its mechanisms and determinations at the local level of the decision arena. No technical issue concerning the infrastructure improvement for population growth in the area or local environmental fragility and vulnerability to flooding has been questioned.

All Urban Expansion, Logistic and Vertical Housing Zones, which were established by the City Master Plan, are located in the surrounding area of the Juqueriquerê River Basin, which indicates the meticulous requirement for the urban expansion historical data because the conflicts in land use and macro drainage may increase with population growth and ecosystem changes.

According to Article 14 of the EEZ, the Juqueriquerê River basin in Caraguatatuba was classified as Terrestrial Zone 3 (TZ3). This zone considers the areas with agricultural uses and rural settlements, where less than 50% of the primary ecosystems is modified, less than 30% of the area is slopes, and the area is covered with secondary vegetation in the initial or medium stage of regeneration and soils with agricultural suitability. Article 15 says that the management of TZ3 must maintain multiple rural uses with low practices for soil, surface and underground water conservation, increase the agriculture productivity, and avoid new deforestation.

Particularly in the downstream area of Claro River, Juqueriquerê River basin plains the largest concentration of farms and represent the most significant agricultural territorial expression of the Northern Coastline of São Paulo (CARAGUATATUBA, 2012).

The urban modeling analysis and Teixeira et al. (2012), it was possible to verify that the effects of petrol exploration on the regional patterns of land use are directly related to the UTGCA installation because it was installed in a predominantly agricultural use area. Although it is the area with the most appropriate physical features for urbanization in the northern coastline of São Paulo, after the installation of this unit, the City Master Plan indicated industrial and logistic activities regarding the petrol exploration and São Sebastião Port expansion for future use of this area. In addition, the new industrial zone is on the border of Serra do Mar State Park, which indicates a complex and problematic controversy between industrial development and the bioma and biota conservation. Nevertheless, although this effect is the main result of petrol exploration in the regional physical change, the UTGCA EIA characterized it as a restricted local effect to the grazing area of Serramar Farm, where the plant was constructed, and considered the impact to be of medium importance and magnitude (TEIXEIRA et al., 2012).

According to Feital et al. (2014), the effects of the local action situation were divided into direct (technical) and indirect (political) components. The direct component is related to the project, its effects and mitigation, whereas the indirect component is related to the structure of the decision process, public hearings, and public participation in this process. Although the technical-issue discussions represent an “action” to define the effects of the “situation”, which is the environmental process, they do not actually interfere at the environmental-licensing level. These components often appear disconnected. In other words, while some actors are only limited to the discussion and negotiation of the technical component, the others suggest the discussion of political and normative components of the process. This disconnection occurs because of the inconsistency between the roles of environmental licensing and public hearing. The local groups represent the actors who expect public hearings to discuss technical, political and normative issues. The lack of functionality of the licensing process as a tool for both technical and political components make the situation vague and less transparent, which impairs the effectiveness of environmental assessment and management tools.

Conclusion

The methodology to classify the available images aided in analyzing the urban expansion in the study area. The results indicate that in the surrounding areas of Juqueriquerê River, the maps show the tendency of fulfilling the occupation of this region, is where the city overlaps with the remaining areas of vegetation.

This study shows that there is an emergent importance to develop a plan for the occupation of new areas and manage the already occupied ones.

Using the urban modeling processing techniques, we verified that technical components, such as population growth and infrastructure adaptation, should have been considered by the UTGCA EIA as local outcomes of this megaproject. However, the only considered effects were in the notably restricted area of Serramar Farm.

After the installation of UTGCA, the City Master plan had to change its guidelines and started considering the area, which was first declared as the most adequate area for urban expansion of the Northern Coastline of São Paulo, as an ideal area for industrial use. Additionally, because Juqueriquerê River Basin is near the megaproject of São Sebastião Port, the expansion area is now considered suitable for logistical purposes. This change is inconsistent with the present EEZ, which considers this area as most appropriate for agricultural use as it has been for a century after the extractivism of the native forest. This change has the most significant effect on the area and against the interests of some local actors of the decision arena.

There is a misunderstanding from some actors of the decision arena who participate in the public hearings that their social demands and beliefs will be heard and able to change an issue in the participatory process. In fact, in the licensing process, only technical issues have a space in public hearings, which are generally transferred from the local to the state or national levels, which causes a misbelief and general frustration of the actors who participate in public hearings.

The analysis of this study shows that important technical issues such as population growth and infrastructure adaptation were not adequately considered using all environmental assessment and management tools. In addition, it is important to notice that no technical or political components were properly treated with all decision arena actors in the licensing process or could interfere somehow in the participatory public hearings, which makes the environmental assessment and management tools less effective regarding the population expectations and local environmental vulnerability.

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