The Use of Geomatic Techniques in the Management of Land Partitioning and Occupation.

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Abstract
The urban process over the last decades has been characterized by the growth in population and the number of new buildings. In the 50s, one third of the world population dwelled in cities. Nowadays, half of this population resides in large urban centers and in Brazil it has not been any different from this. Presently, about 80% of the Brazilian population lives in cities. The growth of impermeable areas and their influence on urban environment, specially on hydrologic phenomena has led to increasing likelihood of floods and the dissemination of diseases carried by water, thus increasing the demand for technologies that can solve the new paradigms on land occupation. This paper presents a contribution to the management of urban occupation with the aid of geomatic techniques. The methodology used involves the application of "overlay" techniques and the establishment of topologic relationships between the basic information levels such as urban zones, lots, public places and buildings. The use of these basic information layers has enabled us to survey the number of pieces of land that do not comply with the urban legislation. The methodology presented here consists of a tool for the management of land occupation and optimises the use of conventional methods of command and control. The water basin of Jacarepaguá Lowland, a peripheral urban area and Rio de Janeiro's expansion area, has been chosen as case study. The results indicate that 70,27% of the lots in the Rio Morto catchment are not in compliance with the legislation for the area. The methodology developed in this study has objectively and clearly stated operational aspects, thus enabling its use in other areas.

Introduction

Since mid XX century, there has been a steady increase in the world's population, nowadays estimated in 6,5 billion people with about 48.7% living in urban areas, in contrast to 29% in 1950. It is expected that by the year 2008, 50% of the world's population will be living in urban centers (UN, 2005). When analyzed as a whole, 11 countries house about 4 billion people (61.5%), and all of them have at present high urbanization rates in their territories. They are: China, India, the USA, Indonesia, Brazil, Pakistan, the Russian Federation, Bangladesh, Nigeria, Japan and Mexico. In this group, eight countries are considered developing countries. In Latin America, the average urbanization rate is of 76.14%, and in Brazil this process has affected the whole country, since 80% of it is population now resides in urban centers, in comparison to the 36.2% in 1950 (MINISTRY OF CITIES, 2006).
Urbanization disturbs the ecological balance causing qualitative and quantitative environmental changes, mainly to the water resources. In this context, the imperviousness resulting from urbanization leads to a sensible reduction in the infiltration rates, thus decreasing water storage in the aquifers and consequently affecting the baseflow. Runoff is intensified, increasing in speed, frequency and magnitude the stream peek flow, occasionally resulting in floods. The uncontrolled population growth may contribute to qualitative and quantitative water resources exhaustion. Urbanization also implies changes to river courses and the bottoms of valleys which are gradually covered by roads and other urban equipment, leading to the siltation of plains and the higher frequence of floods. Additionally, urbanization contributes to a change in the precipitation amount, a rise in temperature, changes to the micro-climate and to the spreading of some diseases (SCHUELER, 1994; PIMENTEL DA SILVA et al., 2005).
Although the legislation that regulates land partitioning and occupation has existed in the city of Rio de Janeiro since mid XIX century, this legislation has been inefficient, due to the dynamic character of the urbanization process. Despite the body of rules prescribed by the government that regulates over various aspects of urbanization configuration process with preventive measures (urban plans, master plans, urban development plans, etc.), corrective measures (re-ordainment-programmes such as *Favela-Bairro* [turning slums into districts]) and effective measures (policies to provide housing and infrastructure), these often reveal the contradictory complexity of their norms and regulations, involving conflicting planning concepts and thus being systematically disrespected by social agents. They also show a historical lack of social concern clearly expressed in the several models of urban management carried out in the city. Only recently has this issue begun to be addressed.
Therefore, it is absolutely essential that, not only in Brazil but in the world, the demand for efficiency in urban planning and management processes, takes into consideration the different social, economic, political and environmental vectors. On the other hand, the success of this process is closely related to the possibility of capturing, assessing the consistency, classifying, storing and analysing spatial-time data derived from the

process itself, as well as the correct availability of this information and, if necessary, its immediate correction, to maximize the efficiency of the planning process and management. In this context, the Geographic Information Systems (GIS) are in line with the new paradigm. The GIS's are interactive computer based systems that use data and models to identify and solve spatial-time problems. Additionally, as the GIS's analyse and cross the compiled data to graphically represent the spatial-time phenomena, they provide greater accuracy in the decision making process (MALCZEWSKI, 1999).
To this purpose, this article aims to present a methodology that encompasses the systematic assessment of the urban zoning and occupation, integrating it to the environmental planning and management, particularly that of water resources. The methodology presented allows for the monitoring of the urban process, with constant data supply and update, as well as fast combination, analysis and spatial visualization of the available data, so as to contribute to the decision making process in the urban environment. Additionally, this methodology allows interface with other similar urban systems, such as IPTU[1] and licensing systems.

Methodology
The methodological approach suggested here uses digital cartographic basis on cadastral scale of the area under study, stored in a database, and includes: (i) a representation of the urban zoning plan and its respective sub zones; (ii) a representation of the information plan on the lots, as well as the building plan with its respective polygons designed, that is, with identification and area attributes; (iii) the creation of access route plans, such as highways, roads and streets. The determination of the value of the lot areas and buildings has been made based on the respective digital representations projected on the horizontal plan. Based on the information plans it is proceeded to establish the relevant topographic relationships between the lot plans and the urban building plans, in accordance with the zoning legislation.
After establishing the relevant relations, the next stage is to enter the data in the data bank with the records related to the buildings in each lot, together with the total area projected for each building in its respective lot. As this is a computer based operation carried out in the database, when relating the area occupied, expressed in the horizontal projection of the buildings, to the area in each lot, an occupation rate is calculated, thus producing a theme based information plan representing the lots in the area under study according to their occupation rate. This plan is classified according to the occupation percentage rate in relation to the zone/sub zone where the lot is located, thus allowing for a spatial visualization of the lots which are not in accordance with the indices established in the legislation.

Results
The methodology presented here was applied to the case study of the Morto River catchment with 9,4 km² of drainage area in Jacarepaguá, an area in expansion in the city of Rio de Janeiro (***Figure 1***). Currently, about 12% of the catchment area is occupied by dwellings, restaurants, recreational areas and a water park. There are also some industries in the area, especially pharmaceuticals. Regarding the zoning (Law nº 322 of 3rd March 1976 – Partitioning and Occupation in Jacarepaguá), there are special zones 1 and 5, or ZE-1 and ZE-5, in the catchment area. The legislation for ZE-1 does not allow for the parcelling or route planning, except in the case of subdividing lots which have at least 1000 m² and are abutting existing public places. In the case of the ZE-5, there is a subdivision in A-23, A-45A, A-45B[2]. The legislation regulates the application of index-based criteria, such as Minimum Recommended Lot Area, Area Usage Index (AUI), Total Building Area (TBA) and also Occupation Rate (OR).
The Occupation Rate (OR) index directly reflects the percentage of the lot area occupied by the building in the horizontal projection and is, therefore, an important tool for the zoning management and occupation of urban areas. This index can also be used as an indicator of the imperviousness of the catchment area.
The digital mapping in a 1/2000 scale was adopted for these studies (IPP, 2004) and ArcGis (ESRI) system, together with Microsoft Access were used to generate and manipulate the plans of information. After applying the proposed methodology, a total of 156 out of 222 lots were identified, or 70,27%, presented OR values not complying with urban legislation for the study area. In ***Figure 2***, the non-complying lots were represented in red. A greater percentage of irregular lots is found in the zone/sub zone ZE-5/A-45B, where there is a greater number of residential lots, as well as middle class condominiums. The lots located in the sub zone A-23 were not taken into consideration because the area related to this zoning is very small in comparison to the total catchment area, and does not have any lots.

[1] IPTU - Urban Housing and Land Tax.
[2] In the specific case of the OR for sub zone A-45A, the same values apply for residential areas, regardless the fact that they are for one or more families, as well as for commercial areas, that means 30% of the lot area. However, for the sub zone A-45B the use is also residential, again, for one or more families, but the value is 10% of the lot area. Still in the same context, for the sub zone A-23, it is established a 30% lot area occupation rate for residential and commercial use.

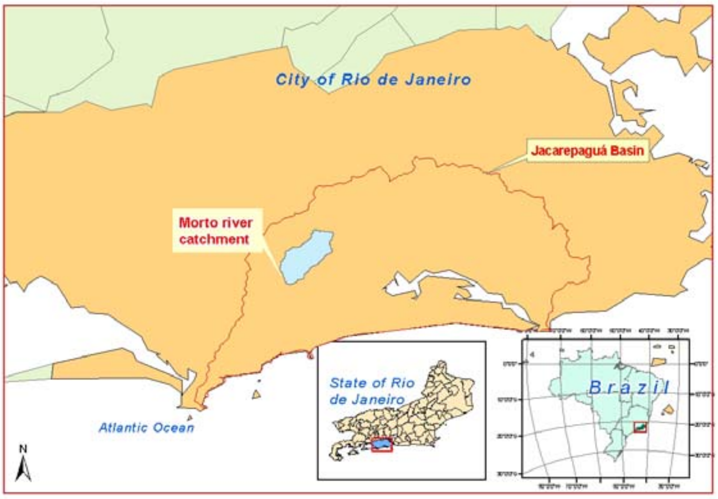

Figure 1 - Localization of Morto River Catchment, Jacarepaguá - City of Rio de Janeiro - Brazil

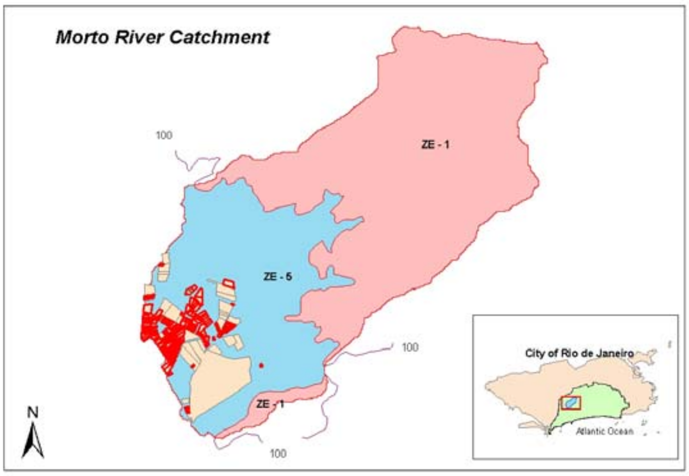

Figure 2 - Lots Not in Compliance with the Occupation Rate (OR) for Morto River Catchment Area

Conclusion

This paper presented a methodology based on geomatic techniques to control urban occupation integrating it to water resources management. The methodology involves mathematical operations from digital thematic maps that result in the information plans about the occupation rates in the lots. Furthermore, a final thematic map can be generated pointing out the lots, which are not complying with the urban legislation. This methodology was demonstrated through its application in a case study on Morto river catchment area in Jacarepaguá, an area in expansion in the city of Rio de Janeiro, Brazil. It was identified that 70,27% of the lots located in the Morto River catchment area were not complying with the current urban legislation. It is important to emphasize that this methodology does not intend to replace the existing mechanisms of command and control, but to act as an extra tool to increase the precision in the decision making process, integrating both urban and water resources management. The proposed methodology does not only present the catchment as an area of integrated urban and water resource planning, but also allows for scenario simulations concerning both urban occupational growth and water resource studies, especially by simulating the effects of imperviousness on the stream flow chart on the urban flood control studies. Finally, the methodology created enables a greater interface with other similar urban systems such as IPTU and licensing systems.

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Figures Captures

Figure 1 - Localization of Morto River Catchment, Jacarepaguá - City of Rio de Janeiro - Brazil
Figure 2 - Lots Not in Compliance with the Occupation Rate (OR) for Morto River Catchment Area