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URBAN PLANNING IN SUB-BASINS ACCORDING TO HYDROLOGICAL MODELING PROCESSES SUPPORTED BY GEOPROCESSING

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In Brazil the Statute of the City law guarantees the appreciation of landscape concept and highlights the importance of preservation of environmental values. The work aims to support the application of sub-basins territorial units in urban planning. It defends the use of GIS tools to facilitate the introduction of these concepts and to have a three-dimensional view for decision-making by overlapping variable components and promote a better understanding of territorial complexity. In a case study it´s demonstrated how to get free data by Digital Elevation Model of ASTER images to built the hydrological model and generate different levels of sub-basins and the river channels. The water pathway was modeled by accumulation grid which allows to respond, for example, in cases of dispersed pollutant in a territory and its diffusion in space, and helps the environmental planning of antropic occupation of the territory.

KEYWORDS: Planning in sub-basins, Hydrological Modeling, Geoprocessing.

INTRODUCTION

Brazil lives the difusion of the principles contained in the Statute of the City (Estatuto da Cidade). Although it has already been published ten years ago, it´s only now that his principles are begin to be reflected in the actions of public planning and municipal anagement. This law 10.257 of 2001 ensures the appreciation of the concept of landscape and highlights the importance of preservation of environmental values. However, the majority of the tools provided by this law have focused the applications regard to the land use question and studies of carrying capacity of urban occupations - such as consortium of operations, transfer of the right to build and onerous grant of the right to build - but doesn´t achieve the desired providences regarded to environmental care.

This work aims to provide conditions for the operating principle of territorial units for sub-basins and to apply this territorial division to plan the notable features of the landscape - such as the ridge axis (watersheds), hilltops, and the headwaters of talwegs stormwater drainage - so that they can be properly considered in the actions and interventions of propositions of urban space. It is argued that the use of geoprocessing tools significantly facilitates the introduction of these concepts, as well as allows the visibility of the landscape arrangement of these elements in order to provide its representation and management. The geoprocessing, by presenting models of representation of landscape, assists decision making by three-dimensional view by overlapping variables system components and encourage understanding of territorial complexity.

It develops a case study in the pilot area with the objective of demonstrating the existing resources and gain knowledge argue that one can have with the hydrological modeling of the territory. From data obtained by the free Digital Elevation Model of ASTER images, or even contour lines provided by IBGE, the hydrologic model is produced, from which are identified in an automated procedure the different levels of sub-basins, and water channels are generated to compose the drainage system. The path of the water is thus modeled by the construction of grid accumulation matrix, to be applied, for example, in the case of simulating a pollutant dispersion in a given position of the territory and its diffusion and consequences.

The developments of the investigations can be used to support the distribution of activities in the territory, the studies of load capacity of territorial occupation, the identification of areas suitable for the preservation and sustainable use of urban space. Our work focuses on the movement of water, its insertion in the process the city growth and development through sustainable planning. Water is vital biochemically, but also carries deep cultural and social values. The city's development is a political and ecological process, and can be discussed from the theorization of mobilization by water. Focusing the relations of access and exclusion, the struggle for water lies on the controversial issue of how water became a commodity, since it was brought to the urban area.

CURRENT SITUATION OF THE MANAGEMENT OF URBAN CCUPATION IN BRAZIL

To understand the current situation of the management of urban occupation in Brazil, we use the 1988 Federal Constitution. The Constitution establishes the bases of a policy for urban planning, specifically the articles 182 and 183. With the promulgation of the Constitution, municipalities with over 20.000 inhabitants or that are part of a metropolitan area were forced to propose a Master Plan. Basically, it is through them that the management of urban occupation occurs in Brazilian municipalities.

In 2001, through Law 10,257, establishing the City Statute, the articles 182 and 183 of the Constitution of 1988 were regulated. According to Santos (2011: 256), "with the City Statute, the guidelines for participation gain objectivity, by enrolling in the law mainly different mechanisms and instruments for participation, which should be further detailed and complemented by other channels of participation through Master Plans, to form a municipal system management and democratic participation, taking into account local realities. "

Moura and Freire (2012) argue that:

"Completed 10 years of promulgation of the City Statute, we can observe what can be identified as his legacy: The Master Plans acquired a central role in public policy, initiated in the 1988

Constitution and strengthened with the creation of the City Statute in 2001 . Faced with the responsibility to lead changes and corrections through sustainable occupation of Master Plans, there is a tendency to privilege actions and local values, what means to promote the characterization of the territory according to its components and its history of formation and transformation. It is also necessary to recognize the potential and constraints in municipal spatial transformations, as they will be the basis for public policy proposals."

The instruments contained in the Statute of the City are configured as great tools for dealing with land issues. Although the statute provides urban policy instruments for environmental management of urban space - such as the need for approval of the Neighborhood Impact Study (Estudo de Impacto de Vizinhaça – EIV) for construction of projects and activities public or private – the environmental issues are not exactly valued and considered in the Master Plans.

Costa, Campante and Araújo (2011: 175) explain that there is a predominance of plans that incorporate environmental discourse in their objectives and principles, through concepts of sustainability and environmental quality. Most often, however, despite the discourse presented, have not been provided mechanisms or instruments to give concreteness to environmental policy. The same authors argue that "environmental issues that feature prominently in the current debate as the effects of climate change and the need for technological innovation to promote new environmentally sustainable practices in buildings and patterns of urbanization and mobility also remained absent in the Master Plans In general, the environmental issue appears unrelated to regional planning policy and the issues of urban infrastructure, major outbreaks of Master Plans, being reserved, in most cases, assignments related to ecology as motes privileged and limits of performance for this theme."

GEOTECHNOLOGY, MULTIPURPOSE CADASTRE AND THE MANAGEMENT OF LAND USE

Because of its transdisciplinary character, geoprocessing comprises a set of techniques for acquiring, processing and analyzing spatial data. It explores techniques of Remote Sensing, GPS, Digital Mapping, GIS (Geographic Information System) and modeling of the territory. As part of geotechnology, GIS is intended to storage and promote the characterization of the territory and to built its spatial analysis, presenting tools that are very helpful in a municipal management. Like any technological area, the speed of their innovations demand, increasingly, a continuous learning to meet the challenges of changing spatial reality.

The GIS is also related to modeling, which is attempting to simplified representation of the reality and is an important step in finding solutions to environmental variables. The risk of subjectivity in this practice can be mitigated with adjustments or calibration processes, so the model should be checked by applying to a known situation and only then be validated.

According to Moura (2005), the proposals to consider human factors, working with participatory planning, and the need to be aware of the complexity and interactivity of spatial phenomena, resulted in studies based on the complexity in recent decades, like systemic analysis, Gaia theory and Caos theory. They are movements that are aware that spatial phenomena are constantly changing and are in close inter-relationship, and simple changes in one variable causes effects of irradiation results that can reach worldwide. With the proposed of new consciousness emerged the principles of Sustainable Planning.

The absence of reliable data of the territory occurs in most of the municipalities. The importance of structuring the Geographic

Information Systems and Multipurpose Territorial Cadastre (Cadastro Territorial Multifinalitário – CTM) is related to the principles advocated by the City Statute, which aims the social and democratic management of national policies at all levels of government.

The existence of a CTM is an important tool for decision support in the areas of sanitation, environment, transportation and housing. From the CTM data are generate conditions for preparation the Plant Generic Values (PGV), the properties tax calculation, the calculation of the ITBI (taxes on the Transfer of Real Estate), contribution rates of improvement, onerous grant the right to build, intercropped urban operations, among others. The CTM provides technical means for making decisions to implement the instruments of the City Statute and make the property fulfills its social function.

Characterizing the complexity of the urban questions, Monteiro (1976) explains that "Cities are complex systems, open to flows of energy and mass, and characterized by a continuous process of change. The concentration of built and verticalized area, resulting in rapid expansion of the urban fabric, implies changes in the behavior of meteorological parameters. Disturbances in the mechanisms of heat exchange between the surfaces and the atmosphere results in instability, altering the dynamics of the air and therefore the characteristics of the atmosphere, especially in local scale. "

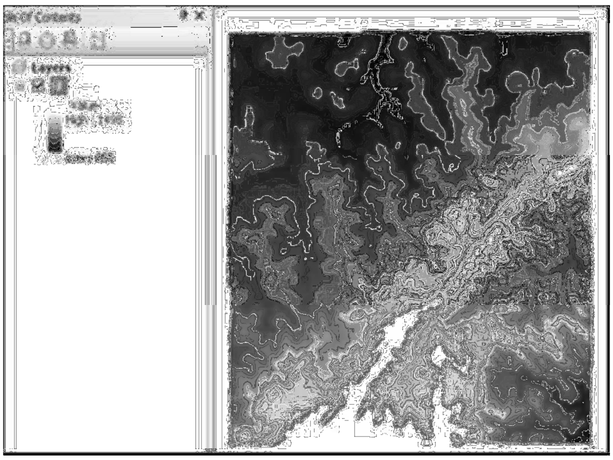
METHODOLOGY TO WATER RESOURCES MODELING

The analysis tool used in the case study allows to better understand the environmental characteristics of a watershed and its occupation, opening more possibilities for planning the territory. To reach the final result there are some steps to be followed: the first is to use the a tool that provides the creation of the hydrographic network of the region, according to the proposed level of analysis, reaching the boundary delineation of a watershed.

For that, we use as a data base the ASTER images - Advanced Spaceborne Thermal Emission and Reflection Radiometer, choosing the ASTER GDEM layer (Global Digital Elevation Model) that have altimetric information with spatial resolution of 30m, and are available for free.

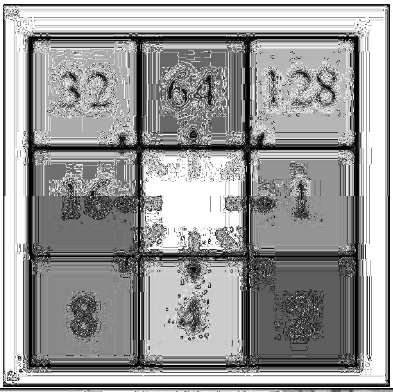
To built the network model hydrologic is necessary to go through a series of processes. The first of these processes is to correct errors on values of altimetry in some pixels of the matrix, caused by difficulties in capturing data from the territory, generally in very rugged and irregular topography. To correct this values the algorithm obtains information from the nearest pixel.

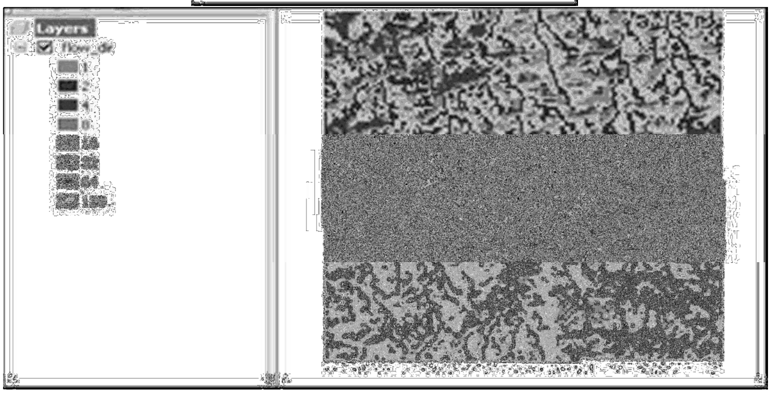
Figure 1: ASTER image after altimetric correction



After correcting the image and altimetric values, it follows to a stage where a file is created indicating a flow direction for each pixel based on the values of the pixels altimetry around you and in the eight directions of existing options - North, South, East, West, Northwest, Northeast, Southeast, Southwest.

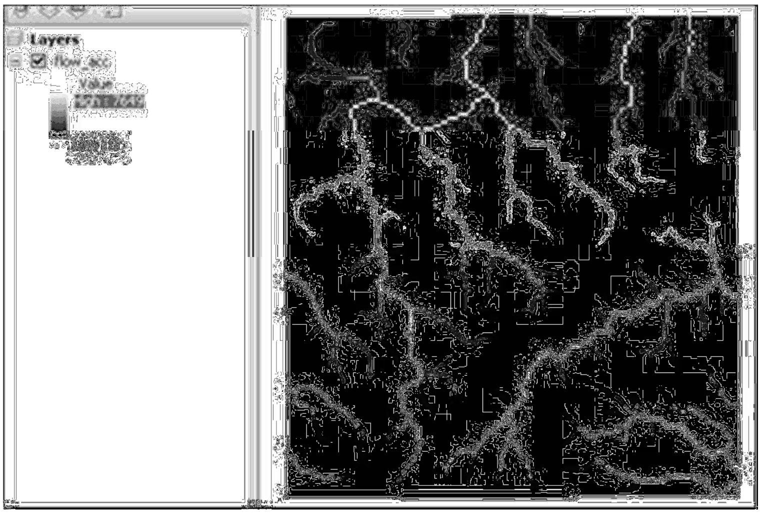
Figures 2 and 3: Representation of flow directions. Image showing the flow directions of the region.





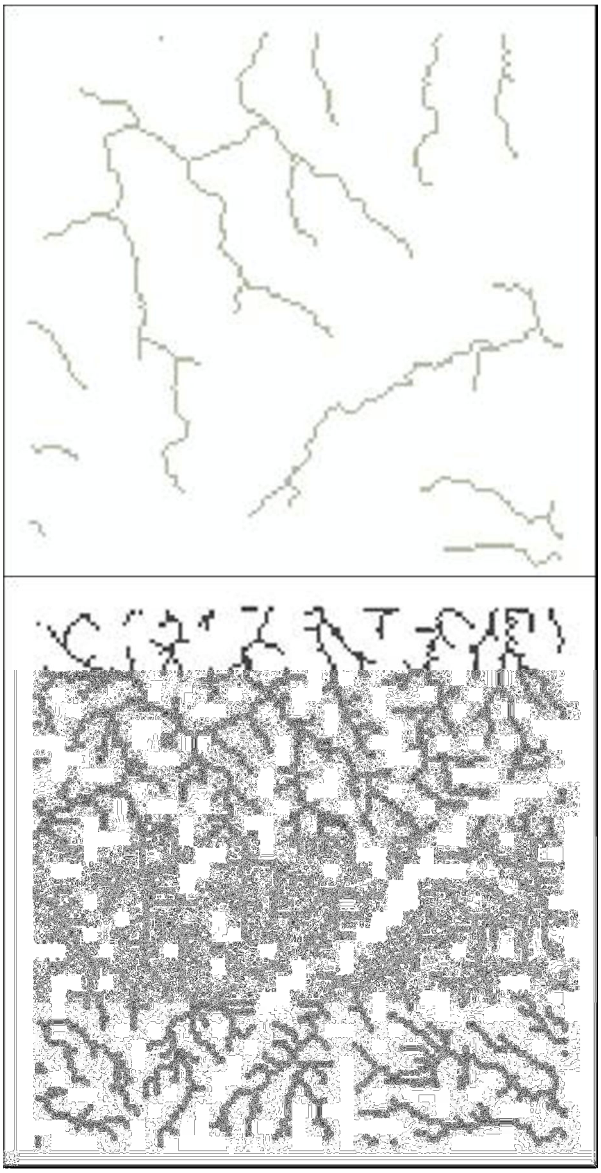
From the flow directions it is possible to determine the direction of water flow, and the next step of the model process is to define the accumulation flow and the threshold that defines the level of the identification of a water resource. The matrix of accumulation represents volume of runoff, relative to adjacent pixels and their values and direction of flow, and informs the higher or lower values of accumulation.

Figure 4 : Accumulation matrix. Higher values indicate places with large accumulation of water.



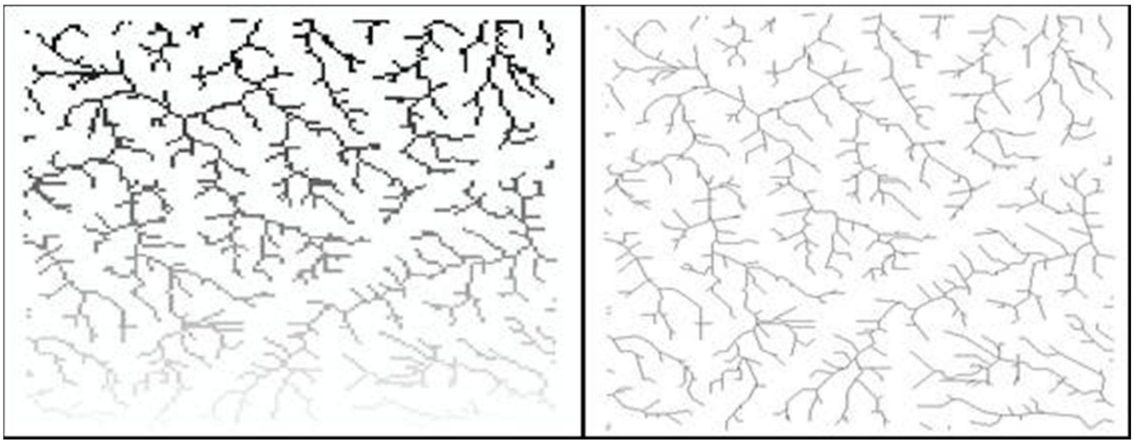
To define the level of accumulation desired for analysis is necessary to define a threshold value indicating the minimum volume of accumulation which forms a recognized river system. The pixels whose values of accumulation are below the minimum stipulated will not be considered part of the water network. This threshold of what will be or not be considered waterbody is according to the objetives of the user of the system, will be given according to the scale of the investigations.

Figure 5 and 6: Hydrographic network with application threshold of 100. Hydrographic network with application threshold of 10.



Then the connection of the waterbodies is carried out in the building of flow, with a "link" between the drain lines defined previously. This file is presented in raster format, but is possible to convert to vector format.

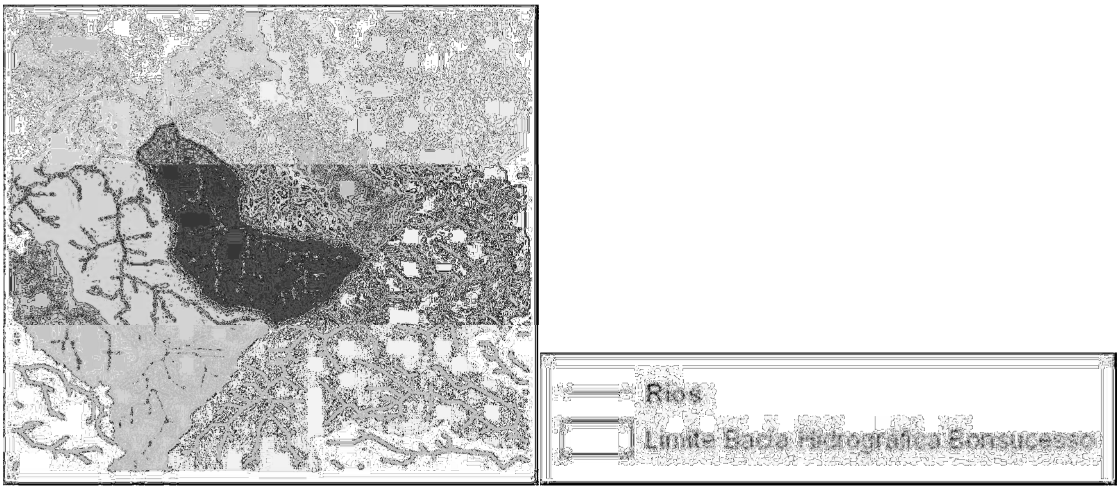
Figures 7 and 8: Hydrographic network in raster format. Hydrographic network in vector format



The delineation of watersheds, in their different scales, it´s another important tool for analysis and decision making about urban dynamics. The consideration of watersheds as planning units can represent large gains to urban planner, offering support to decide about preservation of water resources, as well as the identification of environmental impacts and defining ways of acting.

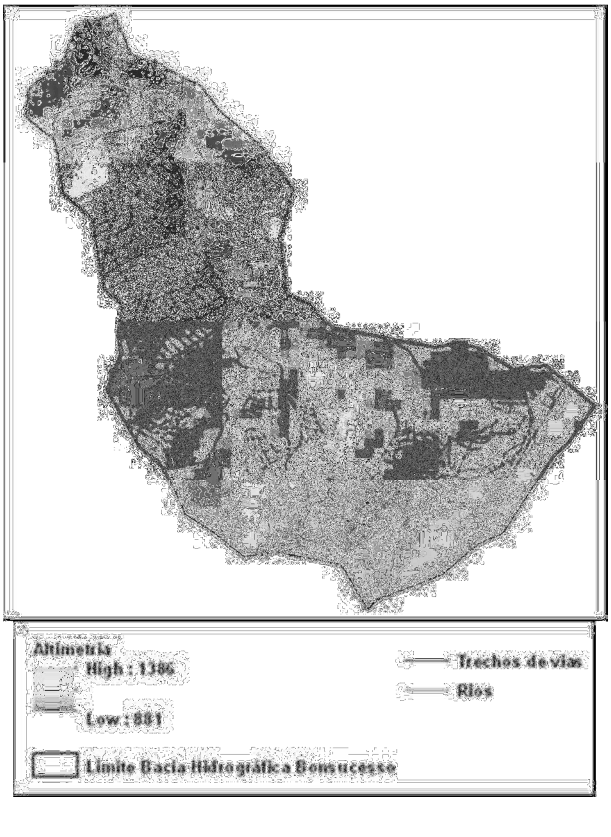
The watershed model also depends on the level of analysis, and it is possible to generate basins, sub-basins and micro-basins, depending on the objectives of the study. To generate the watershed is used the file that contains the hydrographic network by setting the threshold of accumulation, that will be the defining factor in the level of coverage of the basin.

Figure 9: Delineation of watersheds in the region overlapping with the hydrographic network



For a better understanding of the morphology of the region, it was applied a tool that simulates a three-dimensional visualization superimposed of others layers, to represent the characteristics of land use, location of roads and hydrographic net that was created.

Figure 10: Delineation of Bonsucesso watershed stream overlapping stretches of the rivers and roads of the region.



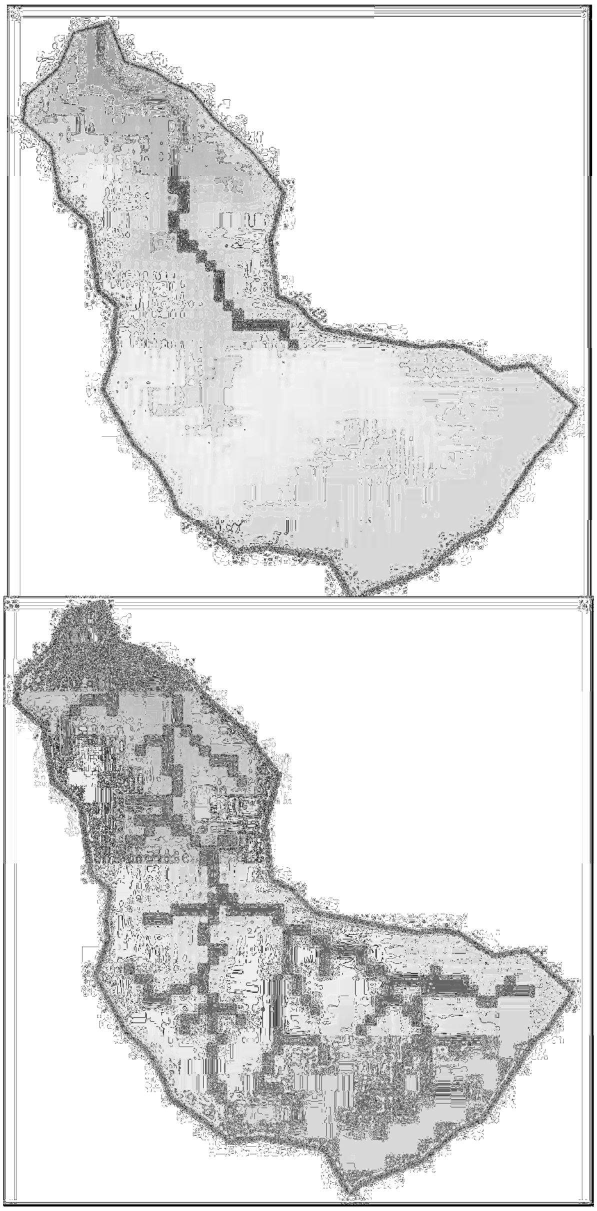
CASE STUDY OF BONSUCESSO WATERSHED

For the study, the methodology was applied to a region in the city of Belo Horizonte, the Bonsucesso watershed. The watershed is located at the Barreiro Regional. It is a tributary of Ribeirão Arrudas River, which crosses the city of Belo Horizonte – almost totally channeled - following the east to the town of Sabará, where it meets the Old River, a tributary of the Rio São Francisco.

The occupation of Bonsucesso watershed is characterized by irregularly. Besides the occupation by large industrial equipment, incompatible with the zoning for the area, it contains several families in risk conditions, due to the high geohazard site, and also due to barriers created by BR 356 and the ring road of Belo Horizonte, and also by the presence of deposits of iron ore waste, construction waste and garbage.

To understand the environmental conditions in this watershed, it was necessary to identify the smaller waterways that make up the supply stream and Bonsucesso. In search of the best values for the threshold, two thresholds obtained prominence. Applying a threshold value 500 we obtained the main watercourses, from which it was possible to detach the Bonsucesso stream isolated, most notably in the area. However, to understand the dynamics that the water originates, we chose to apply a lower threshold, with 10 value, enabling to depth study more specifically set of the watershed.

Figures 11 and 12: Hydrographic network with application of the threshold 500. Hydrographic network with application threshold 500



To delimit the boundary of the watershed the most convenient value for the threshold was 500, because it allowed the modeling the Bonsucesso stream. Using a threshold of 10 for watershed modeling, the results indicated that the micro-basins that make up the larger bowl.

The occupation of areas that are very close to watercourses is a hallmark of the conditions of the watershed (Figure 10), indicating a greater need for attention to the consequences of human occupation, problems and impacts. The use of the watershed as the unit of study provides support for activities of public managers in identifying and/or provide plans to deal with the problems and impacts.

Watersheds, due to its topographical conditions, converge to the riverbeds. So collect as much rainwater as sewage, garbage and any pollution caused by the occupation factors that degrade the region interfering in environmental quality and living conditions of the local population. The areas representing weakness for the watershed are points of attention, indicating a greater need for careful definition preservation or adequated land use.

CONCLUSIONS

A major gains provided by GIS is the possibility of building diagnostics of the space. The analysis of the characteristics, strengths and weaknesses of the space, urban or rural, allows a greater knowledge and domain for land use and better conditions to the management and planning of the territory.

The facilitated access of data and application of the methodology presented was one of the main factors for the choice of the tools used in the present study. The free ASTER GDEM images provides data in good spatial resolution. As compared with SRTM images (Shuttle Radar Topography Mission), for example, which have a resolution of 90m, the ASTER fits better the urban studies, because it can be used in studies that require greater detail, as is the case study of Bonsucesso watershed.

The methodology is easy to learn and can be exposed to a class in a few hours. One factor contributing to this is the choice of software, which provides an interface with easier understanding and handling their tools.

It is understood that the tools offered by GIS can expand the applications of climatological studies, best considering the specificities of each region. According to Mills (1999, apud Andrade, 2005), the current urban climatology evolved towards deepening your physical reasoning, using very complex models, but applied to urban settings simplicados (usually stereotyped urban canyons). According to the author, this evolution of urban climatology makes their results in reduced utility for Architecture and Urban Design, which continued to make a more empirical approach climate, based on 'case studies', with narrow objectives and practical.

Moreover, you can see that some climate issues on urban occupation are addressed in a very simplified way, and are considered not of signify priority factor. The difficulties of integration the information and communication between planners and urban managers and professionals in the field of climatology, distancing the two areas hampering the use of knowledge and its application in urban environments, are often applied only in isolated buildings and not considering the context of the overall urban environment.

The incorporation of knowledge of climatology in planning and land management has great potential for changes in the context of environmental quality offered by urban centers today.

According Bitan (1988), Golany (1996) and Rahamimoff (1984), cited by Andrade (2005) climatic information can be used, for example, in selecting the shape and general urban land use, but also in greater detail aspects of such as sizing and characteristics of open spaces, and use of predominant vegetation, and can go to the planning of residential complexes at the block. Kutller (1988, apud Andrade, 2005) considers that the applied urban climatology should address, especially about the sizing and design of green areas (with the aim of reducing the heating), with maintenance of lanes of fresh and clean air, and provide procedures to reduce the emission of pollutants.

To reach the objectives of analysis and point out possibilities of action in the management of the territory, the application of the methodology was satisfactory as it allows greater action towards preservation and quality improvement to population. It is noteworthy, therefore, that the geoprocessing tools, and more specifically digital terrain modeling and composition of watershed modeling and water system are to support decision making in planning and management of urban space, and through accessible data, free data, make possible to be used by Architect and Urbanist.

Although its already well defended in the literature, the scale of territorial planning of river watersheds and its subdivision are still very incipient, particularly in urban environments. The performance of professional planning should consider this reference and geotechnology allow this decision. Studies of this nature are essential for better management of human occupation of the territory and consideration of environmental conditions, especially climatic conditions.

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