

Discussion Topic: Planning for Vulnerabilities – Methods of environmental planning

Technical Paper

**LANDSCAPE TRANSFORMATION BY ANTHROPIC PRESSURE:
CLASSIFICATION BY SATELLITE IMAGES AND MULTICRITERIAL
ANALYSIS**

Danilo Marques de Magalhães¹

Ana Clara Mourão Moura²

Débora Veridiana Brier Leite³

¹ Pesquisador do Laboratório de Geoprocessamento da Escola de Arquitetura da UFMG, aluno do Instituto de Geociências, Universidade Federal de Minas Gerais. Email: danilo_marques@ymail.com

² Professora da Escola de Arquitetura da Universidade Federal de Minas Gerais, coordenadora do laboratório de Geoprocessamento, pesquisadora das temáticas de geoprocessamento aplicado ao planejamento e gestão da paisagem ambiental e urbana. Email: anaclara@ufmg.br

³ Pesquisadora do Laboratório de Geoprocessamento da Escola de Arquitetura da UFMG, aluna da Escola de Arquitetura da Universidade Federal de Minas Gerais. Email: deborabrier@hotmail.com

Abstract

The study presents an application study of methods and techniques of GIS (Geographic Information Systems) in mapping and analysis of urban and environmental aspects in Ribeirão das Neves and Santana do Riacho-MG. They are spaces with quite different spatial conformations, both have in common are in the area of influence the expansion of the Metropolitan Region of Belo Horizonte, while presenting different challenges related to singularities of the interface between human occupation and the need to preserve environmental landscape. The methodology was based on the application of GIS to construct a database resulting from interpretation of satellite images with temporal variation, construction of digital terrain model and other thematic maps, like the risks of occupation according to geology characteristics. There were also elaborated maps identifying areas of permanent preservation, with the representation of hilltops, slopes above 30%, and tracks domains the watercourses. The crossing of this information is made by multi-criteria analysis to identify areas of higher landscape value and priority in preservation, as well as identifying the potential areas of urban expansion. The result is a picture of the evolution of human occupation in the area, as well as to characterize the suitability of this occupation, as seen to support decision-making through action planning, preservation and management. The choice of two case studies aimed to prove the applicability of the methodology. We aim to encourage studies of urban and environmental planning and management with the exploiting the capabilities of GIS.

Keywords: Spatial Analysis, GIS, Urban and Environmental Planning

1 Introduction

Ribeirão das Neves, council member of the metropolitan area of Belo Horizonte, Minas Gerais, had its occupation process in an accelerated manner and without proper planning, taking its

biggest growth in the 70s. The occupation dismissed its main natural resources such as springs, forests and soil and that over the years has generated significant environmental impacts in the region. The city suffers from the stigma of sheltering a large prison, which resulted in devaluation of their territory.

Santana do Riacho reality presents environmental and human occupation different from Ribeirão das Neves. The municipality has landscapes of great value, related to the Serra do Cipó and the National Park of Serra do Cipó, which has been promoting the tourist flow and transformation of the occupation in the last two decades by opening new blends designed especially to medium and high classes. It is observed today that the search for a better quality of life is associated with the fact of living close to the preserved natural environment, distancing themselves from the problems of the metropolis. However, it becomes interesting for the urban population, especially the higher classes of society, only when the bucolic environment offers shops, services and facilities more sophisticated and specialized. In this sense, the region of Cardinal Mota, District of Santana do Riacho - MG (also known as "district Serra do Cipó") has been known for being scenically attractive, being close to Belo Horizonte and accessed by paved highway. Extend The dynamic process of transformation is improved by the implementation of road infrastructure, such as the Green Line and Pro-access program of state government. (Figure 1).



Figure 1 – Figure 1 - asphalt road by Processo Santana do Riacho-MG-010 (Magalhães, D., May, 2010)

Ribeirão das Neves and Santana do Riacho are strongly influenced by Belo Horizonte, but have quite different territorial dynamics, the first being driven by lower land values and the second by the interest in occupying an area of great environmental value. Both municipalities have had their growth and disorderly unaccompanied by planning actions.

It is known that to change this picture the man must know your way to better plan how to intervene in their habitat, so that these problems do not become so repetitive as they are today. Therefore, you need to know about the place before intervening. We need to have better management and planning of urban environmental information in order to reduce the impacts on nature and improvement in quality of life, seeking the maximum harmony between the natural and urban environment.

In this sense, GIS is a set of techniques undoubtedly of great value to the acquisition, management and manipulation of data related to space. With the development of remote sensing techniques could make a big jump in the spatial analysis of these studies, mainly by way of obtaining data that does not require physical contact between the sensor and location.

Thus, this paper conducted a study of environmental and urban growth to the municipalities of Ribeirão das Neves and Santana do Riacho, based on monitoring of spatial changes of different times, sorting and processing of Landsat images in SPRING software and data integration the model of multi-criteria analysis. The goal was to characterize the landscapes of cities and indicate the areas of environmental interest to compare with the axes of growth of the area occupied by urban organizations.

In the process of investigating the use of satellite images were explored different combinations of bands in order to construct representations for different functions, namely: visual communication through the merger with relevant data (ASTER DEM), visual communication, with fusion of panchromatic band, selection of compositions that highlight the spots urban and disturbed areas, which differentiate the vegetation cover and highlight the exposed soil. To perform the temporal comparison, radiometric corrections were applied between images from different times in the composition of bands that favor the classification of land cover.

Once the mapping of the spatial occurrence of soil cover has been done, this information was combined and compared to other variables that also analyzes the potential for urban sprawl, which are: slope, location of permanent protection areas, geological conditions in order to identify priority areas for preservation and areas most suitable for the expansion of urban occupation. The crossing between the variables was performed by analysis of multicriteria using the software SAGA-UFRJ.

The objective was to contribute to the characterization and recognition of the environmental heritage and landscape of the municipalities, in order to generate information for the adoption of measures that generate a new attitude in the process of urban growth and preserve their environmental resources, functioning as a support Use and Occupation Law of the municipalities.

The aim of this study is, mainly, to elucidate the importance of dissemination and integration of GIS technology for the management and decision making related to municipal planning and urban environment.

2 Conceptual bases - multicriteria analysis in the municipal diagnostics

According to Moura (2003) Multicriteria Analysis is widely accepted methodological procedure of crossing variables in spatial analysis. She is also known as Analytic Hierarchy Weights. The procedure is based on the mapping of variables in information layers, and the definition of the degree of membership of each layer and each of its components, in order to combine then with maps algebra and construct the final result. The mathematics employed is the simple weighted average.

The use of Weighted Average creates a space classification, ordinal, which can also be understood as an interval scale. This process can also be used in nominal scale, when the events are ranked according to some criterion of value. The weighting should be done by experts of the phenomena and the variables chosen to the analysis, or by prior knowledge of similar situations. In that case, the possibility of attributing the values improperly is the inverse of the number of variables weighted.

When there is doubt about the weighting of variables there are two possible paths: the *knowledge driven evaluation* and *data driven evaluation*. The first study guided by the vision of the specialists, is guided in the pursuit of maximizing consensus among the experts participating, in order to assign weights and scores for the variables that are the representation of what is known as the state of the art of the phenomenon, in its conditions culturally, temporally and regionally. The second method, knowledge guided by the data, proposes to conduct heuristic approach to

investigate the behavior of the data in the territory in order to extract the reality from the behavior patterns identified, what means the most likely answers to your research.

In this study, the team itself composed an interdisciplinary group, consisting of planners, geographer and geologist, so that the discussions were quite interesting and were guided in the interface between the variables conditions for territorial occupation and what the legislation could support. The studies of conditions of occupancy restriction is justified under the law so that the study can serve as a reference for municipal legislators that aim expedited perform diagnostics at low cost, and which are supporting the decisions on urban growth, mainly aiming at the drafting of the Master Plan.

3 Methodology - the construction of a database

Due to the involvement of the Geoprocessing Laboratory of the School of Architecture at PDDI project, the Master Plan for Integrated Development of the Metropolitan Region, the data were always in significant territorial dimension of the Metropolitan Area and its Metropolitan influence area. It was composed an impressive collection of data, properly trimmed for the municipality of Ribeirão das Neves. This enabled us to analyze the city according to its context of insertion, as well as the occupations and infrastructure of the adjacent municipalities and the region.

3.1. Patches of Urban Occupation - studying the temporal evolution

It was initially promoted a long process of exploring data from satellite images in order to map the patches of urban growth over time, especially in the dates of significant growth in the region.

The processing of the images correction was based on georeferencing and radiometric studies. The georeferencing needed to achieve a standard error compatible with the scale of work, radiometric correction between scenes, since the mosaic required working with three scenes, radiometric correction between the different dates, since the goal was to compare the growth of urban sprawl. Once satisfied that the correction, the land use classification was done, but there were observed much confusion between urban occupation, exposed soil and mining activities.

For the area of Santana do Riacho were used Landsat satellite images from 1987 and 2009, while for Ribeirão das Neves were used the dates 1991 and 2002, since the studies were done in parallel and were chosen dates that had better images for the territories studied. Landsat images have a spatial resolution of 30 meters, allowing the characterization of land cover in areas of great scope for automatic classification, which results in agility, and economy in obtaining information about locations often inaccessible. But a major difficulty of this method is the challenge of distinguishing different types of land use, especially extracts of vegetation. (Santos, 2005).

Was defined a typology for classifying known human occupation, consisting of areas of urban expansion and mining or other significant transformations of the landscape, which has conferred with other surveys conducted in the region, like the study by IGA (Institute of Applied Geoscience - MG) for the project north of the vector.

Compositions bands were chosen, and radiometric correction was done to equalize images from different dates and different orbits. The color compositions were studied to highlight the features of interest based on the spectral response of the targets studied. According to Rocha (2000), we adopted the composition of bands 3, 4 and 5 in Blue, Green and Red, respectively, for this shows the limits between soil, watercourses and vegetation (Figure 2). For the radiometric correction were used to average values 127 and 45 for standard deviation for a correction with application enhancement.

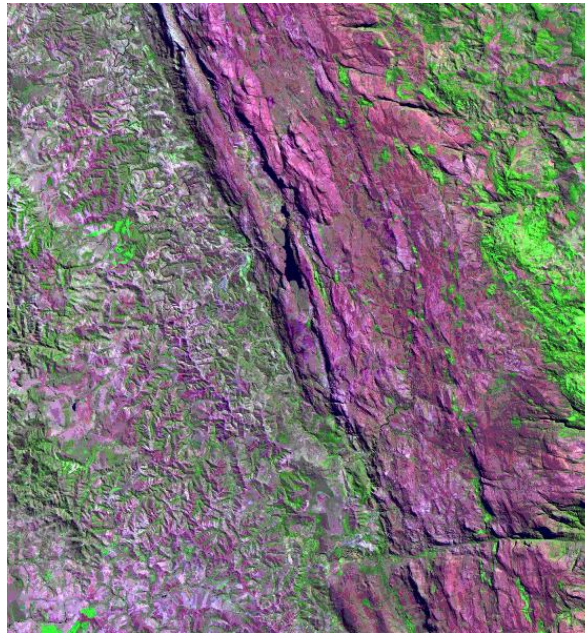


Figure 2 – Landsat Image - Composition of the bands 345-BGR area of Santana do Riacho

With equalized images were done the segmentation process, which basically consists in grouping pixels with features like color and texture. For this, the variation was granted up to 15 shades of gray in each segment. After this segmentation process, samples were collected in the very image of what would be the types to be classified. Classes indicated bare soil or urban occupation, dense vegetation (riparian forest and rainforest), shrub (cerrado), low vegetation (grass, country rock) and water or shade. Once obtained the ratings of patches of urban occupation and vegetation cover in time scale, they have been collated in order to stress the spatial evolution of the occupation. Figure 3 shows the exemple of Ribeirão das Neves.

The application and the model used for the study of temporal comparison was the model of "Monitoring" and the use of measurement called "Signature", both available in the software Saga-UFRJ. The Monitoring "is the exhaustive survey of the environmental changes occurring in a particular environmental situation" (Xavier-da-Silva, 2001), what the study meant to identify the areas that became exposed soil or anthropic use where before there was another type of use (undergrowth, shrubs, etc.). Subscription now allows "once defined an occurrence of interest, the database can be consulted on which the environmental characteristics that are located in the target area" (Xavier-da-Silva, 2001), which if allowed to quantify, for example, what were the types of date before they became exposed or anthropic use soil in the most recent date.

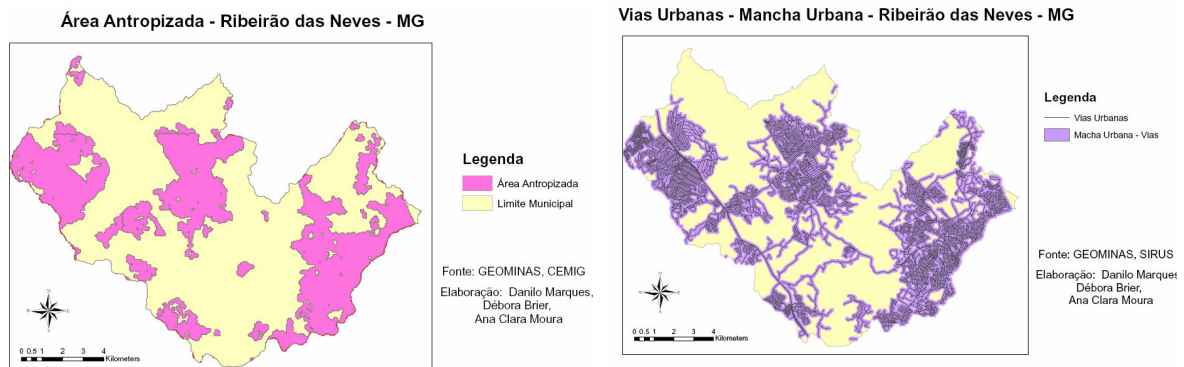


Figure 6 and 7 - Urban patches area from grouping the posts and urban roads in the territory

The analysis of the contents of the statement results in the identification of areas with pathways released, but without electrification, which brings us to the location of urban voids that would not be so easily separated in the classification of high resolution images. Another interpretation is the probable routes of growth for the presence of road infrastructure, characterized by the already existing paths that connect to the anthropic land use patch installed. It would, however, verify the existence of spatial barriers to such growth, which was performed through studies of the topography - slope and hill top.

3.3. Permanent Protection Areas

From the contour lines on 1:50.000 scale generated by the IBGE and digitized by Geominas project, were generated digital terrain maps and maps of hilltop and slope (Figure 8).

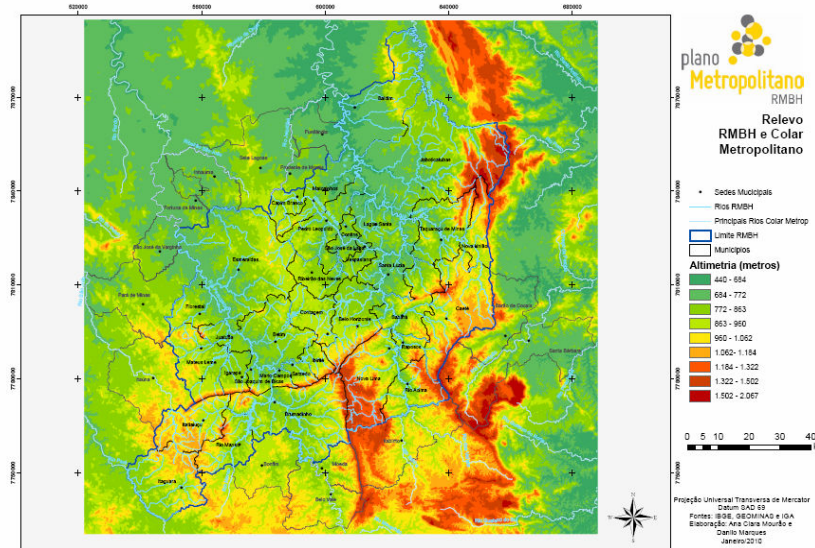


Figure 8 – Digital Terrain Model and Topography of RMBH

The slope map highlighted areas with slopes greater than 30%, because they are considered permanent protection areas (PPAs). Also highlighted is the range between 30 and 47%, whose occupation is authorized geotechnical report (Law 6766/79). It was also performed the map of water courses influence area, depending on their widths and types, which resulted in the buffer of 100 meters on the shores of reservoirs, buffer of 50 meters in the bands of watercourses larger, and buffer of 30 meters in the edges of waterways of smaller width (Figure 9).

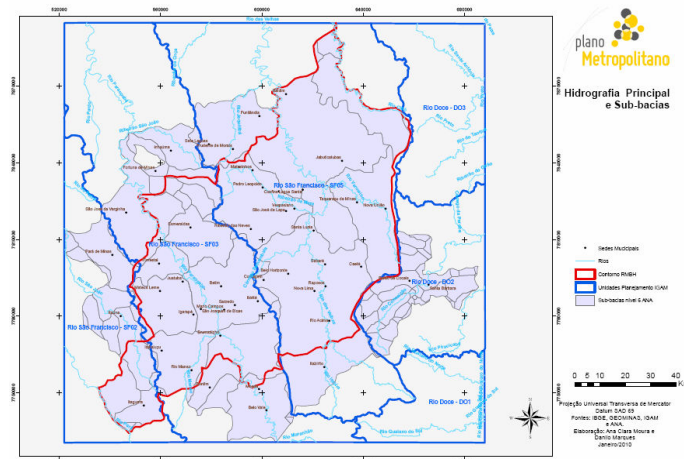


Figure 9 – Main hydrography and watersheds in RMBH

The mapping of the hill tops is still a matter of some controversy in defining areas of APP, because according to the methodology adopted, the tools employed and the scale of the cartographic base used results can be quite different. This reflection was presented by Cota on his dissertation in the IGC-UFGM (2008) other reflections of the author (2007 and 2009).

The methodological criteria adopted was to structure the digital terrain model of the entire metropolitan area, followed by identification of watersheds defined by the ANA - National Water Agency. Further, the topographic reality was targeted by the units of watersheds and in each of them were extracted the values of lower elevation and higher elevation, to define the last third part. This held in all the watersheds resulted in the sum of slicing in each region the hilltops, that were summarized to conform the maps for the RMBH (Figure 10).

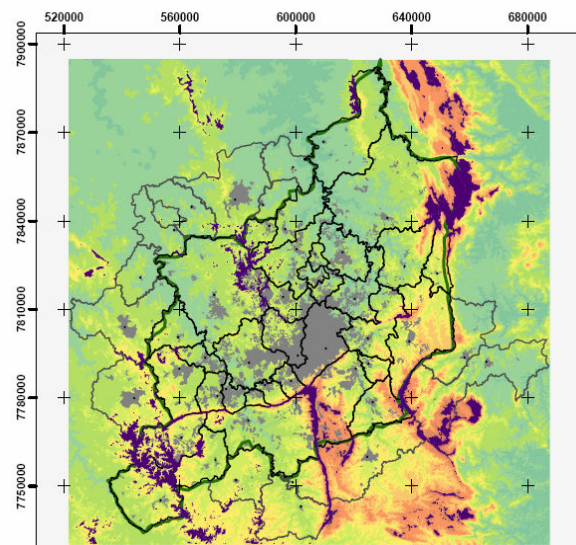


Figure 10 – Urban areas and hilltops defined by watersheds.

The map produced highlights the slopes, the tops of hills and ranges of area waterways in the municipalities. Figure 11 shows an example of Ribeirão das Neves.

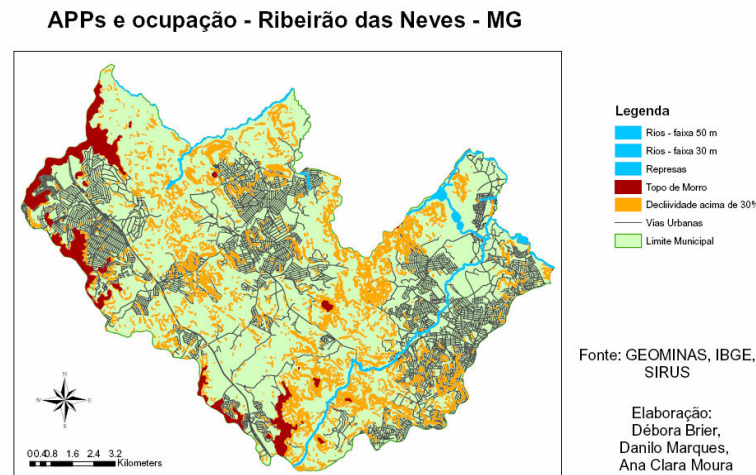


Figure 11 – Slopes, hill tops and with the hydrographic network of roads

It is observed in the case of Ribeirão das Neves, who fit the urban settlement in the valleys between the mountains of obstacles, but is dangerously expanding the limits of the municipality in western region of hilltop. The areas formed by the high slopes segments the territory into regions, but there is a considerable area in central municipality in which the slope would not be problematic, there would be no risk of impact to water resources, there are encouraging access roads and yet, it is not occupied. Is the occupation of Ribeirão das Neves so conditioned and driven by neighboring municipalities, to the point of its geometric center, with good infrastructure and access, be less attractive than their edges?

A declividade até 5% não é considerada de restrição à ocupação segundo nenhuma normativa, a não ser no caso de coincidência com talvegues e faixas de domínio de cursos d'água. No entanto, sempre que realizamos estudos urbanos, temos o cuidado em mapearmos também essa faixa, pois a consideramos de alerta aos ricos de ocupação, devido aos riscos de inundação. A questão é bem mais grave quando observamos que essas baixíssimas declividades se encontram em talvegues espalhados de rios, mas ao mesmo tempo encaixados entre montanhas de alta declividade, como é o caso de Ribeirão das Neves (Figura 12). São áreas de inundação com ocupação já consolidada e em expansão. Mas continua a pergunta: por que a área mais central do município não é ocupada? Não seria o caso de implementar política de incentivo a esse novo pólo?

The slope up to 5% is not considered a restriction on occupancy according to the rules, except in the case of coincidence with tracks and watercourses domain. Nevertheless, when we do urban studies, we also map out this slope, because we consider of warning to the risks of occupation, due to flood risks. It is quite dangers when its observed that these very low slopes are on sprawling rivers, and at the same time embedded between high mountains, as is the case in Ribeirão das Neves (Figure 12). Inundation areas are already occupied with consolidation and expansion of urban areas. But the question remains: why the more central area of the municipality is not occupied? Should we not implement policy to encourage this new area?

Declividades de Risco e Ocupação - Ribeirão das Neves - MG

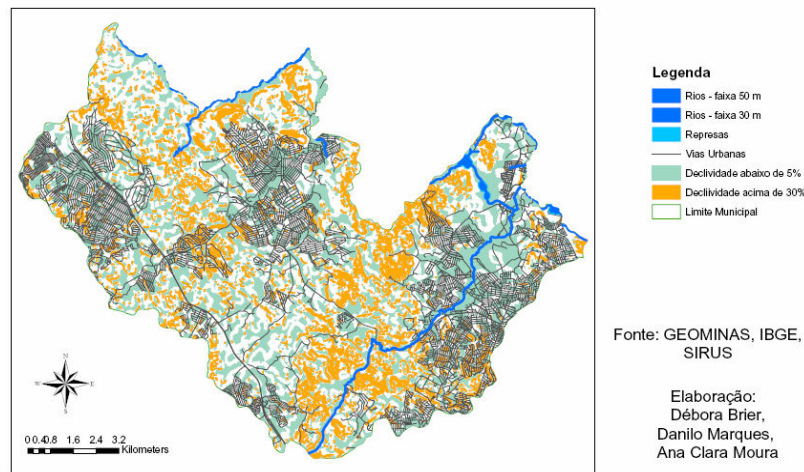


Figure 12 – Risk slope - Above 30% and below 5%

3.4 Geology, Geotechnical units and Conditions of Occupancy

As a collaboration to PDDI Project (Integrated Master Plan of the Metropolitan Region of Belo Horizonte), Prof Maria Giovanna Parizzi produced from the geological map of the area done by CPRM (Geological Survey of Brazil), a map to identify geotechnical topologies and their degree of risk to the occupation. The methodological approach adopted was the study and interpretation the many units and sub-units in the existing geological map of CPRM and proposal of a second group compositions according to their similar behaviors. The result was the identification of 10 types of geological units related to the risks of occupation. Given this result, the author stated the criterion scale from 0 to 10, presenting the worst and the best conditions for the urban occupation of the territory from the viewpoint of geological composition (Figure 13).

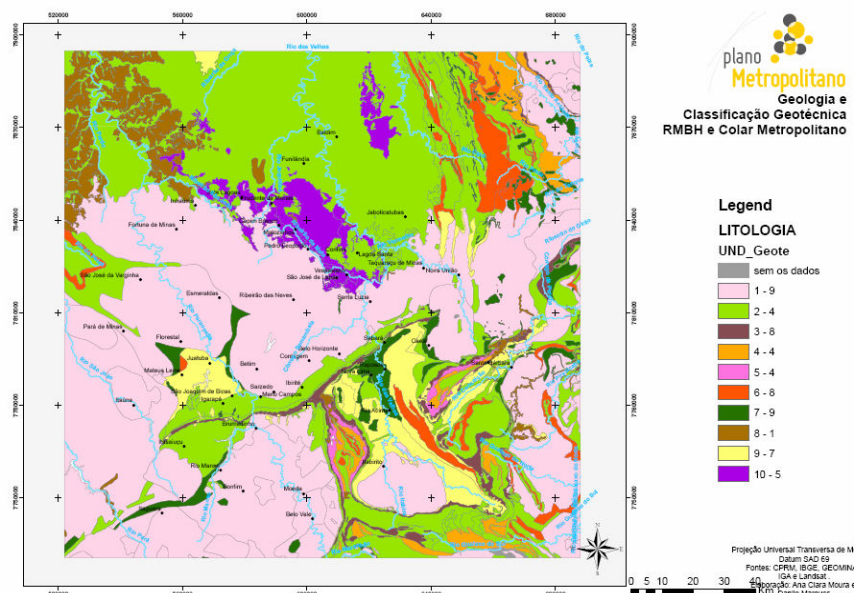


Figura 13 – Geology - Geotechnical Classification (left column in the legend) and degree of risk to urban occupation (right column in the legend).

The map was used in studies related to the subject in RMBH, through the association of other constraints, but it in itself was an important contribution to studies of urban growth in the region and its surroundings, since it indicates the areas most vulnerable and most appropriate the occupation.

In the specific case of Ribeirão das Neves, all the territory is in the same geotechnical unit, which is suitable for urban occupation, with restrictions only in case of soil change (erosion and landslides) and may fall block. However, near the municipality in the north-northeast, there is a very worrying geotechnical unit, characterized as low to the occupation and potential problems of karstification, collapse and contamination of groundwater.

It is important, therefore, to observe the conditions of use of the county and assess whether the main pathways influence the growth of this area towards the worst conditions of occupation, which was obtained through the map which also highlights the roads (Figure 14).

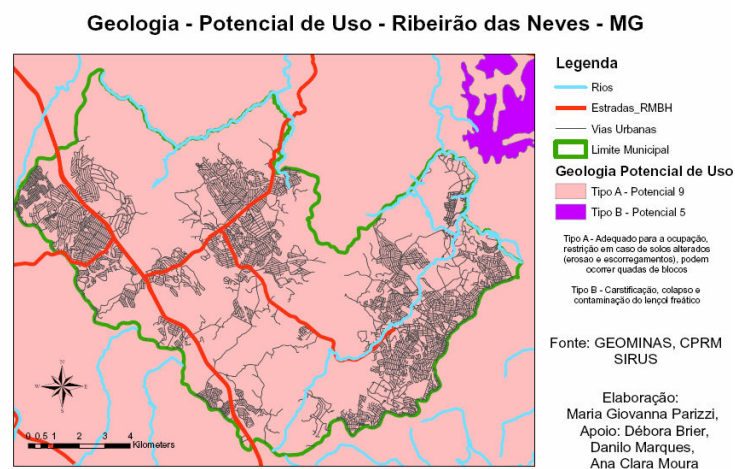


Figure 14 – Potential use according to geological risk, evaluation of inducers of growth through roads and evaluation of water courses at risk of contamination.

Another point to observe is that the region which has geological risk due to karstification has weaknesses and risks of contamination of groundwater. It then noted that there already exists a dense occupation along the stream that moves in Ribeirão das Neves towards this area of environmental fragility (Figure 15).

In search of more information about the risk of expanding this occupation, the research enlarged the observation area, and it was observed that there is a great road that promotes the link between Ribeirão das Neves and Sao Jose da Lapa, which conforms to the way risk contamination of that fragile area. However, other studies have identified San Jose da Lapa as an area of significant growth potential, which means risk of urban sprawl in this region, resulting in environmental impact assessment (Moura, 2010).

It is noticeable that the buffers of water course (SW-NE direction) coincide with the conurbation areas between Belo Horizonte, Ribeirão das Neves and Vespasian, in a district known as Justinopolis, a region that will be greatly transformed by the projects for the North Vector (City Administration of the State Industrial Airport) (Figure 15).

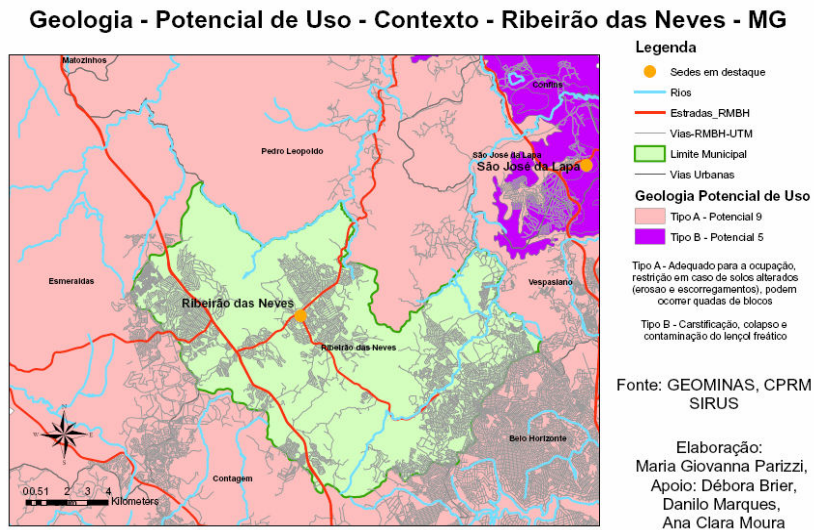


Figure 15 – Potential use according geology - the context of Ribeirão das Neves

3.5 Maps of changes of occupation - an increase of urban sprawl

The study of evolution of urban sprawl were more detailed in Ribeirão das Neves, whereas the processing studies plant cover and growth of the area disturbed were more detailed for Santana do Riacho. For Ribeirão das Neves, from classification of satellite imagery and procedures of clusters of electric posts versus the analysis of the road network was possible to prepare a map depicting the area of urban occupation until 1991, 2001 and 2009 (Figure 16).

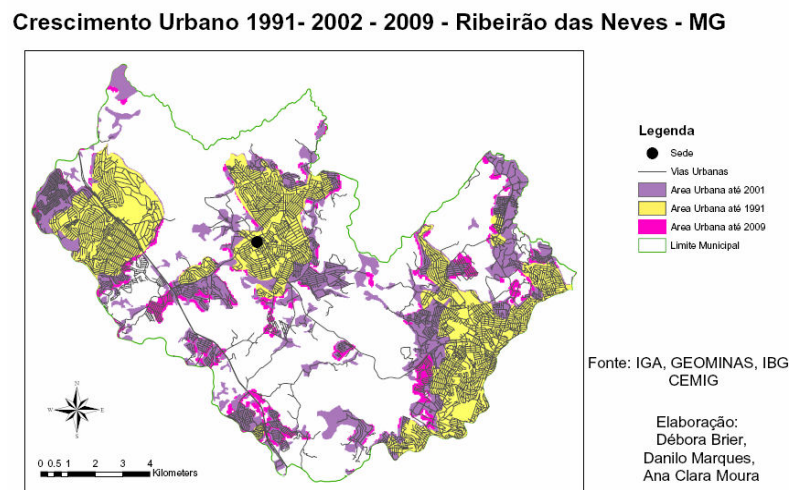


Figura 16 – Growth of urban sprawl

The map was taken to the software SAGA-UFRJ, in order to be subjected to analysis of "Signature". The process involves calculating the areas of quantitative spatial occurrences. In this case, the goal was to obtain information about the percentage and numerical values of the areas of each year according to the occupation of areas of restricted occupation (APP) or risk occupation (slopes below 5% at risk of flooding)..

3.6. Multicriteria analysis for synthesis of degree to the growth of the occupation

The identification of areas suitable or unsuitable for human occupation was made from a cross by multicriteria analysis. Were combined maps of Areas of Permanent Preservation (APP) of a watercourse (Article 2 of Law 4.771/65), Top of the Hill (CONAMA Resolution No. 303 of 2002) and land with slopes exceeding 47% (Law No. 6766/79), geological map according to risk to urban occupation (Parizzi, 2010) and land cover classification generated by the satellite images. Figure 17 illustrates the case study of Santana do Riacho.

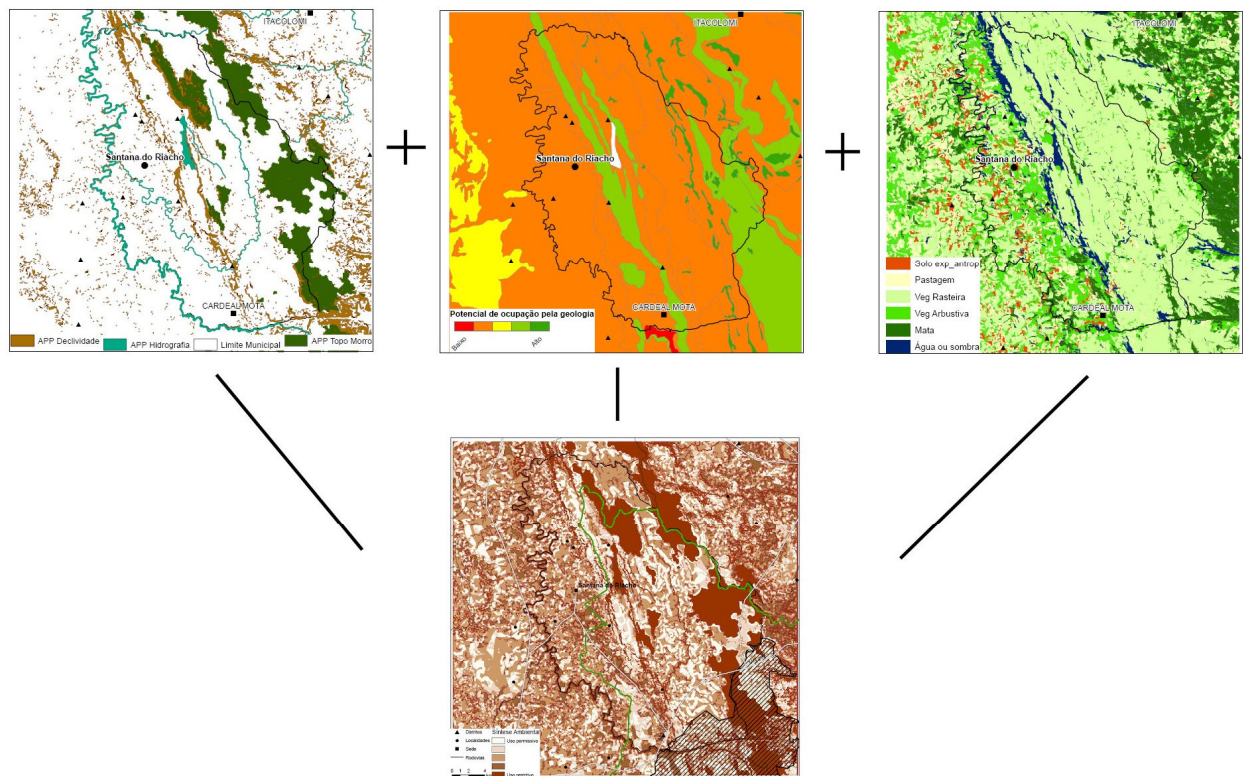


Figure 17 – Example of Santana do Riacho - diagram drawing up the Environmental Summary. From left to right the Sum of APP, with the Geology and the Land Cover

According to Moura (2005), Multicriteria analysis is a methodology based on the crossing of variables for plan information and the definition of the degree of relevance of each plan for information and each of its components caption for the construction of the final result, using the weighted average.

For construction of the synthesis of vulnerable environment, which demonstrates the impediments to urban occupation, were applied notes from 0 to 10 to classify areas ranging from full permission to occupation (note 0 = urban area, areas of slope less than 30% off the APP on stable lithology) to the total restriction on occupation (note 10 = APA, slopes exceeding 47%, unstable lithology and preserved forest). All maps were considered of equal weight at the time of crossing the same, ie each received a weight of 20% in the general sum.

4 Results and Achievements

The analysis should evaluate not only the conditions of urban expansion from the point of view of its suitability and environmental legislation with restrictions on permanent protection areas, but also the mode of acquisition and analysis of information in order to observe if it consists and improvement on methodology. The goal of analysis is to indicate the procedures to adopt in other municipal diagnoses, reason for the two case studies developed in parallel.

4.1 Mapping the area of human occupation

The study evaluated the appropriateness of using the variable “electric posts” as an indicator of the degree of anthropogenic alteration of the territory. The response is that the variable is very interesting, not only because it creates a spot of concentration, but also is an indicative of occupation in fact. It is noteworthy that the electric power service in the state of Minas Gerais is the order of above 90%, supply planning, and in the metropolitan area is nearly 100%. Thus, the mapping indicates the occupation in fact, because where there is human activity is electrifying.

4.2 Study the temporal evolution of the occupation

The classification of satellite images and comparing time through the "Monitoring" on the Saga-UFRJ, produced a map of expansion of areas of exposed soil or anthropic land use. This type of product helps to understand the routes of expansion, as well as the identification of what gave rise to new occupation.

In the case study from Santana do Riacho, for example (Figure 18) the analysis shows that the type of land use has expanded in parallel axis to the barrier imposed by the Espinhaço Mountain and follow roughly the direction of the highways in the region . This proves the importance of the roads to induce the expansion, and alerts that the new programs of development will increase the flow of people and goods in the region. There is also an axis parallel to the ongoing expansion of Rio Cipó (western boundary of the city) because the proximity to water courses is attractive for occupation, which is cause for concern, since the removal of native vegetation cover can lead intense soil erosion and consequently affect the quality of water and sand these rivers. The vegetation has been transformed in the vicinity of the headquarters of the municipality.

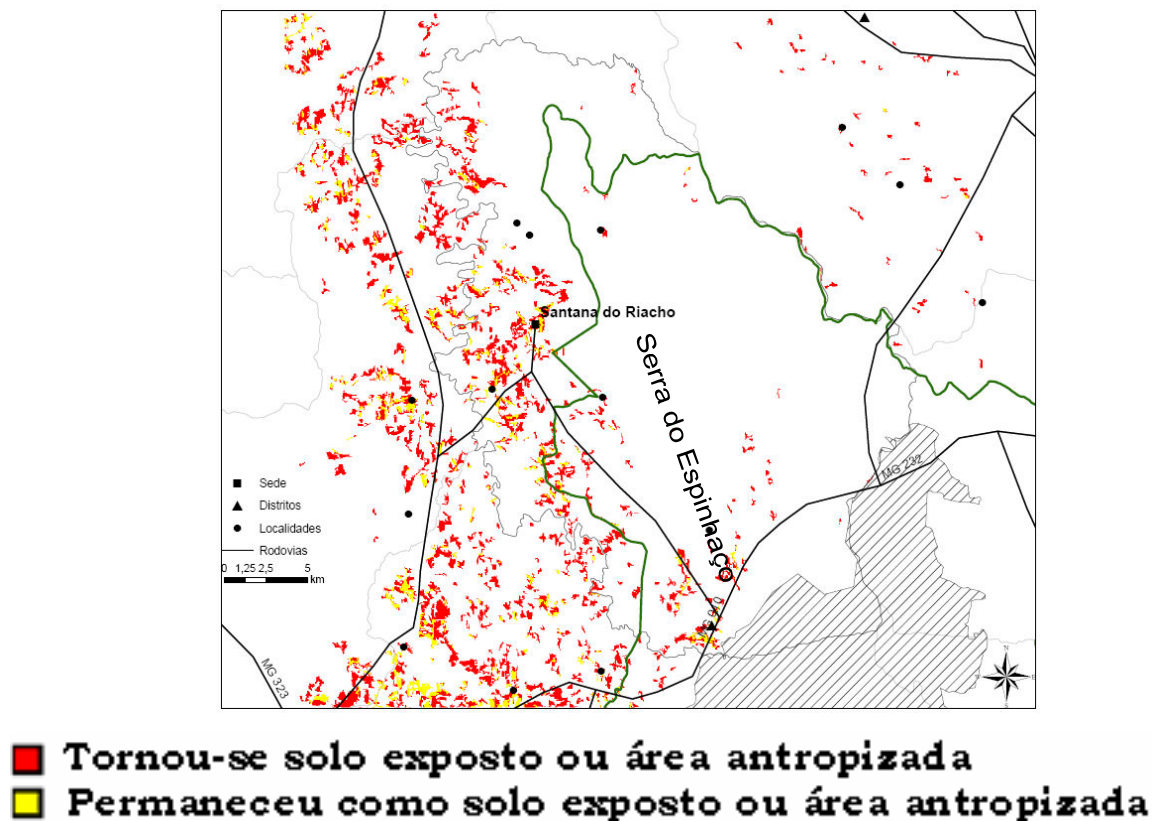


Figure 18 – Map of expansion of areas of exposed soil or anthropic land use

The methodological approach of using satellite images of medium resolution, free, available dates from the middle of the 80s up to today, and providing automatic classification in the free software Spring was very effective, both in case study of Ribeirão das Neves as in the case study of Santana do Riacho.

The methodological procedures of "Monitoring" and "Signature", developed in free software SAGA-UFRJ, also proved quite effective, reporting on what has remained as it was, what has changed, and detailing what has changed over the information that was replaced for that transformation happen.

4.3 Studies of synthesis variables by Multicriteria Analysis

The synthesis of variables can be developed on free software Spring, with some degree of difficulty (requires programming skills in language "Legal") and quite easily in the software SAGA-UFRJ, also free, in the manifold "Evaluation". Must be mapped variables of interest and they should be combined by assigning weights and grades for algebra procedure.

In the study of urban occupation in Ribeirão das Neves compared to areas that would be restricted (APP) or who are at risk of flooding (slope below 5%), identifies the region Justinópolis as major environmental concern and risks community (Figure 19). The expectation is that studies like the one presented here will serve to support decision-making and to define priority areas for restoration, maintenance and even shifts of the occupation. Figure 20 indicates the degree of suitability to the occupation in the region, highlighting the problem areas as urban growth in recent years.

Áreas Inadequadas para a Ocupação - Ribeirão das Neves - MG

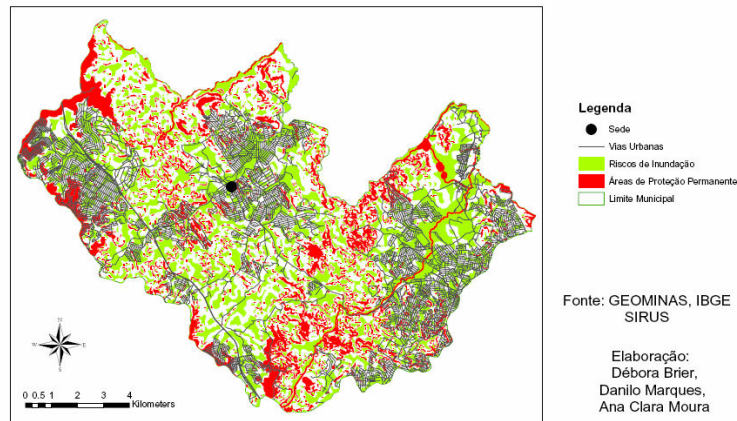


Figure 19 – Areas unsuitable for the occupation - restrictions due to APP and inundation areas.

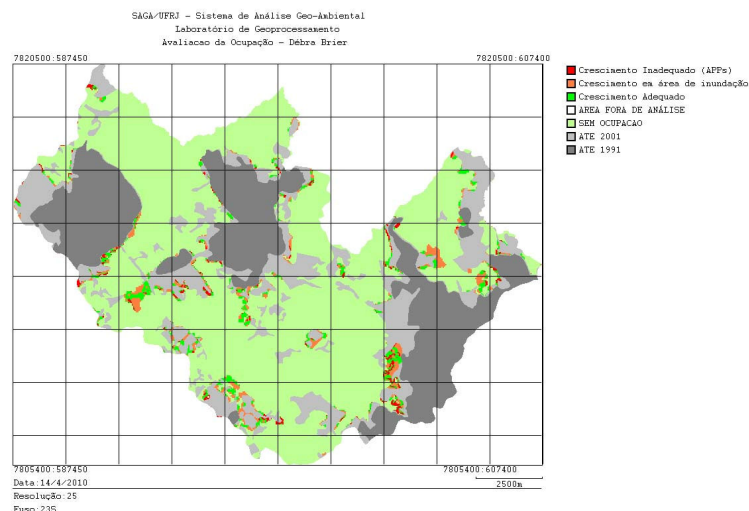


Figure 20 – Highlight the areas of urban growth and assessing the degree of suitability of areas. Inadequate growth in red, orange area at risk of flooding and green in appropriate areas. Gray occupations already consolidated by 2001.

5 Conclusions

The work aimed to present case studies in areas of significant space complexity, strongly influenced by the state capital, and that will be under pressure for transformation due to the projects that favor the vector northern metropolitan area. The objective was to conduct study expeditious and inexpensive to present a first look at the problems of human occupation in Ribeirão das Neves and Santana do Riacho, in order to support the decision-making municipal macro scale. More detailed studies can be performed using the same methodology, without invalidating the answers given here.

It was an option to use free information and free software, that can be accessible to municipal managers and researchers, to propose a methodological guide economically sustainable. It seeks to encourage municipal government in using GIS tools that can promote the spatial visualization and its environmental and urban issues, which will be of great interest to decision-making meetings for master plans or other instruments of urban planning and management.

The option to apply a methodology that is based on the spatial occurrence in studies of combinations of these occurrences and the construction of summaries of studies of potential, such as the potential for urban expansion and synthesis of priority areas for conservation, provide support to decision-making. The methodology favors the submission of defensible criteria, what means that it can be questioned and calibrated at any time, reflecting values and priorities of the community. This means acting in achieving a balance between preservation and development. This means acting in a sustainable manner in the planning and management of environmental and urban landscape.

6 References

Moura, Ana Clara M. (2003), *Geoprocessamento na Gestão e Planejamento Urbano*. Belo Horizonte, Ed da autora.

Moura, Ana Clara M. (2010), “Estudo exploratório de aplicação de métricas de paisagem na caracterização da dinâmica de transformação regional – potenciais de transformação das manchas urbanas”, in *Anais VIII Encontro Nacional da Associação Brasileira de Estudos Regionais e Urbanos - ENABER*, Juiz de Fora, Brasil, UFJF. pp. 1-22.

Cota, Maisa de A., Moura, Ana Clara M. (2009), “Áreas de preservação permanente (APP) - estudo de caso sobre o parâmetro declividade e as divergências nos resultados de mapeamento em função das bases cartográficas e escalas e/ou softwares utilizados”, in *Anais do XIV SBSR Seminário Brasileiro de Sensoriamento Remoto*, Natal, Brasil, v.1. pp. 3697 – 3704.

Cota, Maisa de A., Moura, Ana Clara M. (2007), “Análise de Situação das Áreas de Preservação Permanente (APP's) em relação ao Uso e Cobertura do Solo através de imagens Landsat e Ikonos, em Pitangui e Conceição do Pará, Minas Gerais”, in *APPUrbana 2007 – Seminário Nacional sobre o Tratamento de Áreas de Preservação Permanente em Meio Urbano e Restrições Ambientais ao Parcelamento do Solo*, São Paulo, USP.

Cota, Maisa de A. (2008), “Áreas de Preservação Permanente (APPs) - Discussões sobre as resoluções Conama No. 303/2002, 302/2002 e 369/2006 e o papel das técnicas de geoprocessamento nas identificações das classes de preservação”, *Dissertação de Mestrado em Geografia*, Universidade Federal de Minas Gerais.

ROCHA, Cezar Henrique Barra (2000), “Geoprocessamento: tecnologia transdisciplinar”. Juiz de Fora, Ed. do Autor.

SANTOS, Nádia A. P. (2005), “Uma abordagem metodológica para determinar a influência do uso e da cobertura do solo como fonte de poluição difusa na alteração da qualidade da água na Bacia do Rio das Velhas”, *Dissertação de Mestrado em Geografia*, Universidade Federal de Minas Gerais.

XAVIER DA SILVA, Jorge (2002). “Geoprocessamento para análise ambiental”. Rio de Janeiro, Ed. do autor.

MAGALHÃES, Danilo Marques, MOURA, Ana Clara Mourão, LEITE, Débora V. Brier. Landscape transformation by anthropic pressure: classification by satellite images and multicriterial analysis. Niterói, 4th Urbenviron International Seminar on Environmental Planning and Management - Niterói 2010 – Sustainable cities for the new millennium. Escola de Engenharia da Universidade Federal Fluminense, 18 a 21 de outubro, 2010. 17 p.

7 Acknowledgments

We thank the valuable collaboration of CEMIG - Companhia Energetica de Minas Gerais, for providing data of GEMINI Project for the investigations of PDDI - Integrated Development Plan for the Metropolitan Region of Belo Horizonte.