Tools to decision making in conflicts of interests on metropolitan and local scale: the role of the geo-technologies based on GIS and Parametric Modeling of Territory Occupation

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Abstract

It presents discussion on new trends in the planning of complex urban areas. It defends the role of geo-technologies, GIS and the Parametric Modeling of Territorial Occupation, as instruments of great efficiency in decision making. Argues that the territorial changes in urban scale occur in two ways: by urban surgeries and by parameterization of the occupation. Presents a methodological proposal to act in regional scale and in local scale, based on Geographic Information System and modeling, to characterize a context and simulate a local reality. It argues about the importance of investing in visualization in order to promote wider involvement of the society. It discusses how to act on conflicts of interest.

Keywords: Conflicts of interests, Geographic Information System, Parametric Modeling of Territorial Occupation

1. INTRODUCTION

The urban occupation in Brazil follows the pattern of concentration and crowding in large cities, despite the significant size of the territory of the country. Because of the difficulties of implementation of infrastructure and lack of territorial planning, from regional to local scale, the option of urban morphology has been the megalopolis, by an expressive action of conurbation of urban occupation, overlapping of activities, and generation of a complex territory. Once installed the complex and large urban spots, it is up to the public power the management of conflicts of interest, because there are many actors and dynamics involved.

The urban design is not anymore a product of an authorial proposal, but it has the morphology of something without control. The authorial proposal could be the act of an urban planner designing urban morphologies according to the geography of the site, or even a project of urban occupation that materializes the expectations of the new values and ways of life. However, what is observed nowadays is that this form of drawing urban spaces is being replaced by processes of parameterization of the landscape, as a way of establishment of maximum limits to urban form, according to the territorial capacity and observing the sustainable for the transformations of the territory.

What we advocates is that, even reducing the conditions to design the urban space, the role of the urban planner occurs by the process of parameterization, and the definition of acceptable limits. It is, in fact, the translation of the expectations of society. However, how to involve society in the definition of these parameters, since the processes of display of the information still has to face the difficulties of lack of conditions of the citizens to understand urban legislation and its territorial consequences?

The article presents a methodological proposal supported by geoprocessing that operates in different scales of mapping, analysis and construction of diagnostic and prognostic of urban spaces. It is applied to a case study, the Metropolitan Region of Belo Horizonte, Minas Gerais, Brazil, that is a

complex territory composed by 34 municipalities, with more than 5 million inhabitants, and a territory of urban conurbation area that has 49300 hectares.

On this scale are constructed studies to identify areas of environmental interests and the need for sustainable use of space, but also identifies the areas of interest in growth and densification of urban occupation, according to the entrepreneurial vision. The conflicts of interest are identified, and it is a way to prepare the urban managers for the difficulties to be faced. In addition to the conflict, are also identified areas for environmental preservation, areas that need investments of recovery, areas of environmental interest but that have risk of transformation, areas suitable for urban occupation, areas to urban occupation but with environmental care, and areas adequate to investments of transformations.

In local scale, it's fundamental to recognize the lack of conditions of the citizens to understand the propositions of urban legislation and the results of them on urban landscape. To this scale is presented a methodological proposal using geoprocessing to build three-dimensional simulation of the urban parameters, facilitating the visualization of information and, therefore, of better participation in decision making. It is argued that, in the new paradigm of drawing of the territory, there is no more the performance of authorial urban designer, but rather the search for the maximization of consensus in the definition of acceptable limits, the parameters, according to the interests of the community. In this sense, the GIS (Geographic Information System) must develop to the process of Parametric Modeling of Territorial Occupation (PMTO).

The article presents two scales of territory and urban planning: The first scale is the regional planning, with the objectives of identifying the potentialities and the conflicts of interests, in order to establish limits of acceptance and sustainability in the use of a common area divided by 34 municipalities. The second scale is, after considering the limits in regional scale, to propose the urban occupation considering the limits of landscape sustainability in local scale, in urban parameters. As it is an urban conurbation area, the frontiers must be considered and planned in consensus with both municipalities, and must be an agreement of different interests. The parameterization is a way to establish the acceptable limits to the urban occupation in complex changing cities.

1.1. Conceptual bases - Multicriteria Analysis in the municipal diagnostics

The geo-technologies based on GIS are important tools to decision support. About its applicability, Moura (2007, 1546) explains that in instead of simply describe elements or facts; the models of spatial analysis in GIS can outline scenarios, simulations of phenomena, based on observed trends or trials of conditions. The use of a GIS is related to the selection of variables for analysis and the studies of its combinations. They are attempts to simplify the representation of reality, through the selection of the most relevant aspects, in search of answers about correlations and behavior of environmental variables. The system is studied according to a determined purpose or objective, and everything that does not affect this objective is eliminated. The risk of subjectivity can be reduced with processes of adjustment or calibration, when the parameters involved are evaluated. Once calibrated, the model must go through verification process, through its application to a known situation, what is called "validation". Only after validation the model should be applied to situations in which the outputs of the system are not known.

According to Moura (2003) Multicriteria Analysis is a widely accepted methodological procedure of crossing variables in spatial analysis. It 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 other 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 is guided by the vision of the specialists 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, but also considering 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. Both methods can be applied and the results won't necessarily be the same, because the first one tells about what is considered the most adequate situation according to the specialists, and the second one tells about what is predominant according to local variables.

The methodology of Multicriteria Analysis is quite adequate for the employment of geo-technologies in the creation of summaries of variables whose objective is the identification of priority areas for some phenomenon or geographic arrangement. It is based on the very basic logic of the construction of a GIS: selection of the main variables that characterize a phenomenon, already performing a cut-out methodology for simplifying the complexity space; representation of reality according to different variables, arranged in layers of information; definition of plans of analysis in spatial resolutions appropriate for both sources of data as to the objectives to be reached; promotion of the combination of layers of variables, integrated in the form of a system, which reflects the complexity of reality; finally, possibility of validation and calibration of the system, through identification and correction of relationships built between the variables mapped.

1.2. Conceptual bases – Parametric Modeling of Territorial Occupation

We are living in a new era in the drawing process of urban planning and urban management, and this change is the result of developments in the technologies of spatial representation. The era of post-modernism is being replaced by a new moment dictated by parameterization. What preceded this new condition was the significant evolution of geo-technologies, the wide dissemination of their resources and the facilitation of their usage due to the availability of data and applications on the worldwide network of computers. The laws have encouraged the access to information and they also defined that the urban projects are necessarily of collective interest, and because of that they should be discussed and agreed with the participation of the community. This brought as a requirement to issue the visualization of the information.

We defend the division of urban design into three great periods, as a proposal to simplify the history and to construct a parallelism throw urban design and urban representation. We arbitrated this proposal by its alignment with the employed forms of representation of the territory, which are: the period of general composition of cities based on the drawing of morphologies (pre-modernist); the period of decomposition of the landscape in typologies and zoning (modernist); and the period of recognition of spatial complexity and proposition of models to represent the territory (post-modernist). We defend that we are already living in a new stage of transition, after post-modernism, guided by the reasons for parameterizing, calibrating and configuring the anthropic landscape.

We still use the values from the past, as the act of the urban planner is as complex as the changing city itself. From the Pre-modernism we observe the ability to represent the essence of territory in its *genius loci*, with authorial action in the definition of morphology of urban occupation. From the Modernism we observe the rationalization in territorial occupation with inclusion of general normative which should be applied to the homogenous areas, recognized as zoning and related to rigid definition of sectors in the use of the urban soil. From the Post-modernism there is the recognition of the complexity of urban reality and the planning processes in multidisciplinary and transdisciplinary groups, and the GIS had a role to promote the construction of representative models of reality, according to different points of view, for decision support. The values from the

Contemporaneity are characterized as parameterization, interoperability, Geodesign, integration of BIM (Building Information Modeling) and GIS, strong investment in communication and dissemination in the network, community involvement using VGI (Volunteered Geographic Information), legislation to support the standardization, and policies to permit access to information.

But we defend that the authorial urban design is giving place to the parameterization of urban occupation, because it is a way to represent the needs, the values and the expectations of the society. When the limits of what is acceptable and desired are defined, that means parameterization of urban design. So, the urban designer has to construct the capacity to observe, understand, propose and represent this desire of the society, and because of that he must improve tools to support this new way of working.

In this new way of working, there are two forms to transform and to produce the urban landscape: the urban surgeries, which result in local actions in smaller temporal and spatial scale; and the proposals of urban parameters, that are actions of large scale in temporal and spatial sense. The urban surgeries transform the territory very rapidly and expressively, changing the occupation and the image of a place, generating effects of irradiation of results. In the other situation, the application of planning parameters affects the territory more slowly, as product of master plans and their respective laws of land use and occupation. The parameterization defines envelopes or volumetric references for the occupation in local scale, in the unit of lot, but as the action is more global, the visualization of the results happens over time.

The urban surgeries are public and private intervention in the cities, reconstructing part of the urban morphology. It is considered a smaller scale intervention, according to time and spatial reference, because it is a punctual intervention that produces effects of irradiation of results. It began to be proposed when the simple ordination by the functional zoning didn't attend anymore the speed and dynamics of territorial processing. Forward the economic crisis, the urban planning and urbanism acquire a new function, other than merely regulating the private sector. It is the promotion of economic growth and entrepreneurial action for the attraction of investments, to add dynamism to the local economy by redesigning its production chain and redefining its economic role.

According to the interest and the need to make the city a locus of economic production, the planners proposed to shape new images of the cities, within the logic of interurban competition to attract investments. The reconstruction of the city, the design of new spaces, or the remodeling of certain sectors, transform physically the territory to which is associated a new image, renewed, which was called by some authors as "city marketing" and "entrepreneurship" of cities. (Harvey, 1992).

But as the same time, the other axis of activity of urban planning today, which is responsible for transformations in large temporal and spatial scale, is represented by the definition of limits in conditions of territorial occupation, which means establishing urban parameters.

The parameterization itself is not an actual and new principle, but it was born in the laws of streets and blocks installation, in the master plans and their respective laws of land use and occupation, and in the buildings codes. At different scales the parameterization seeks to set limiting conditions or envelopes to the territory occupation.

2. MATERIALS AND METHODS

The objective of this article is to defend criteria and procedures for parameterization for the territorial occupation at a regional scale and on a local scale. The regional scale has as objective to set limits for usages and occupations, as a first analysis, which should be considered by Municipal Master Plans, so that the zonings proposed by each municipality don't be in conflict or not consider the interests of the whole ensemble.

On a local scale, it defends the importance of communication and visualization of the results of application of urban parameters, so that actions of approval of ecological-economic zoning presented on Municipal Master Plans can be understood by the population. From the simulation of

possible landscapes that the zoning can generate, the planners can adjust the limits for urban settings and parameters.

2.1. The regional analysis – Multicriteria Analysis

Due to the involvement of the Geoprocessing Laboratory of the School of Architecture at the Master Plan for Integrated Development of the Metropolitan Region, it was produced an impressive collection of data. In this study, the team itself composed an interdisciplinary group, consisting of urban planners, geographer and geologist, so that the discussions were guided in the interface between the variables conditions for territorial occupation and what the legislation could support.

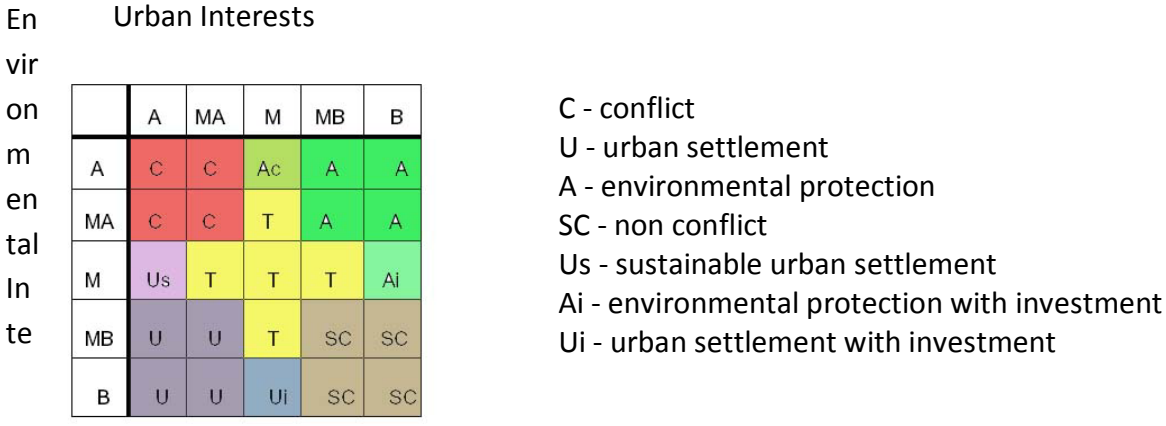
For the application of the methodology in regional scale, which aims is the identification of conflicts of interest, the first step is the selection of themes of mapping and structuring of the cartographic and alphanumeric database. The data is organized in thematic maps, which are converted to raster representation, to make possible to apply the matrix combination of variables. The raster representation is justified because of its implicit topology, needed to the matrix process, which not only optimizes the data crossing, but as also is a condition *sine qua non* in some models.

In order to produce the maps of Synthesis of Environmental Interests and the Synthesis of Interest of Urban Expansion, were selected variables that respond by conditions in the interest of each theme, mapped initially in the form of thematic maps, which is then were converted into potential surfaces of the distribution of the issue, according to the relevance of the variable in each synthesis.

The decision making is defined on the Decision Tree, which is a flow chart that shows how the variables will be combined by the process of algebra of maps. In this work the algebra was weighted average, with the weights and notes suggested by experts (Knowledge Driven Evaluation). The Decision Trees applied established that the Synthesis of Environmental Interests was built from the combination of data about vegetation, geology, slopes, hydrology, topographic aspects, and areas of environmental protection. The Synthesis of Interests to Urban Expansion and Occupation, defined according to the market and business interests, was built from the combination of data considering aspects of facilities but also aspects that are friction or limitation to the occupation. The variables were the characteristics of vegetation, geology and its geotechnical conditions, slopes and the needs of investments of correction and containments, the identification of the axis of urban growth, the accessibility and capillarity of road, and the availability of infra-structure represented by electrical network, garbage collection, sewage system and water resources.

Once prepared the synthesis of interest to urban growth and to environmental interest, they are collated in order to promote the identification of areas where the vocation of occupation and clearly defined, where there are conflicts of interest, as well as where there are specific conditions of vocations and interests (Figure 1).

Figure 1: Matrix of Combination



The interpretation of the results must be explained. The conflicts correspond to areas that have good conditions and market values to the urban growth, but are also of environment values and interests, and because of that we have observed that the political forces determine the final results. The urban settlements are areas in which the urban uses are clearly defined, without conflicts with environmental protection interests. The environmental protections are areas clearly defined to be preserved, without conflicts with urban occupation interests. The non-conflict areas are territories in which there are no potentials for urban growth or environmental preservation, but they are very important to receive sanitary landfills, industrial parks, recycling centers, among others. The sustainable urban settlement areas are those with vocation to urban occupation, but because of some environmental interests, the occupation must be less dense, with better consideration of environmental parameters. The areas to environmental protection with investment are those destined to protection, but with needs of recuperation. The urban settlement with investment area those with vocation to urban use, but must receive investments in infra-structure to be well successful.

The "T" area is especially important to urban planners. It means a transition area, but also an area prepared to be transformed. It is an equilibrium of medium interests for environmental aspects and for urban growth aspects, but as it is medium, if the proposes tends to urban interests, the environmental defenders can accept it, and if the proposes tends to environmental interests, the eentrepreneurs and investors of urban growth can accept it. This area of equilibrium of interests can receive catalysts of urban transformation that have the power to change the use, values and the landscape of the place. This is the most interesting area to urban design planners.

2.2. Parametric Modeling of Territory Occupation

After developing the regional analysis that presents tendencies, priorities and conflicts of interests, it's time to focus on local scale, to transform the zoning observation into local occupation. To arrive to this local scale we have to build a knowledge on spatial perception, to capture from the society its expectations and values, and to propose a settlement typology, which considers existing conflicts and local landscape context. We defend the use of geo-technologies as a support tool for visualizing and communicating urban intervention proposals, also simulating their effects on the resulting landscape.

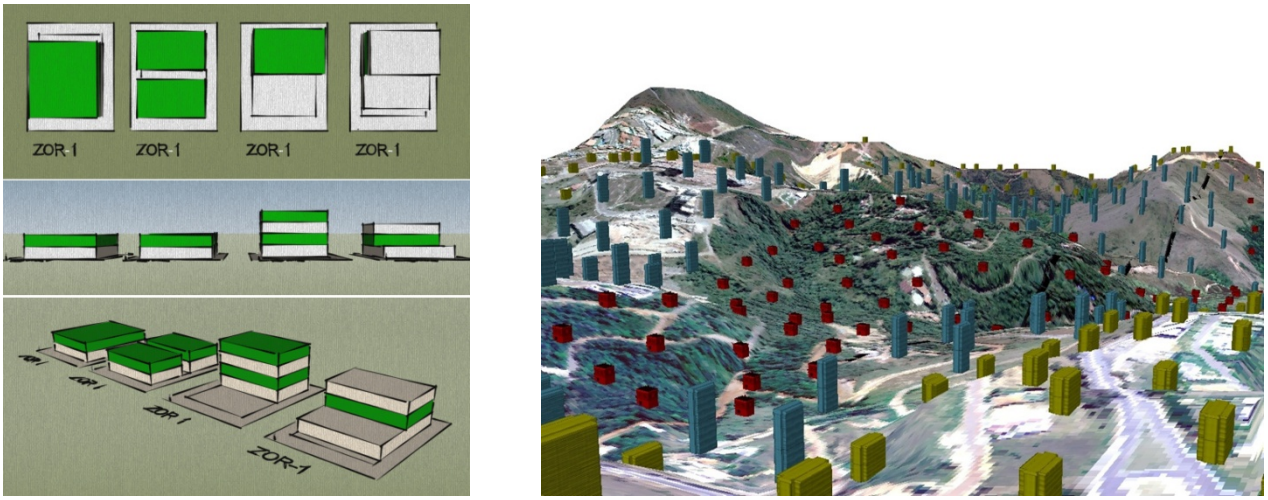
Once the area is characterized according to its potentials, restrictions, possibilities and conflicts of interest, the landscape perception interpretation and representation is undertaken, according to Spatial Perception and Cognition theories. The goal is to lay a foundation for the following phase, which is a project for land use and projection of the resulting new landscape for the district. This stage of perception studies aims to understand not only values involved, from the technical point of view, but also regarding landscape identity values.

As theoretical bases, classical authors are used as references, such as Kevin Lynch (1997) and Gordon Cullen (1983). Lynch's readings help to perceive place through their structuring elements, mental map creation, legibility conditions, landscape identity and singularity. Cullen's readings instigate the identification of place's cognition, considering one's insertion in a landscape and the proximity of all points of view that it encompasses. Both approaches facilitate to identify the district's values and vocations, which are references to the construction of the modeling of landscape proposals. It is important to identify the *genius loci* that characterize the landscape and must be considered in urban projects (Schulz, 1980).

Our goal is the proposition of tables of parameters presenting urban references, bordering the limits and uses accepted for each portion of the territory, as the result of values and expectations of the citizens affected by the spatial transformation processing. (Figure 2). Thus, we believe that the adoption of this set of parameters must happen in participatory process, in which the urban designer can submit his proposals resulted from the investigations on the context, but these proposals must be simulated in visualization of 3rd dimension by dynamic process (Figure 2). This dynamic

process means the possibility of changing, during the discussions, in real time, the proposed parameters, so that the citizens have wide viewing of the possibilities that the new landscape will present.

Figure 2 – Examples of the representation and simulation of possibilities of urban parameters in a single lot, using simple representation scheme (left). Application of zoning and typologies of occupation in simple tridimensional representation, using ArcScene (right).



In our investigations, we observed that many times not even the professional that works with spatial planning has full perception and visualization of results that town planning legislation and tables of parameters may cause. The dynamic simulation of possible transformations and results can make discussions more clear.

The goal is that the citizen understands that he dwells a landscape, and not only a lot. He lives in a place, not in a point of the territory.

It is believed that this new way of designing the territory, by Parametric Modeling of Territorial Occupation (PMTO), can be a way to make the public policies and, above all, the laws of land use and occupation, a collective bargaining agreement built through maximization of consensus and, therefore, must be defended as a consensual decision.

In search of tools that could support us to apply these new concepts and values, we identified some software, and we are living the experience of using a parameterized model to make simulations in real time, testing the results from the urban landscape applications and parameters settings.

The application permits the constructions of rules that produce, volumetrically, the results delimited by the tables of references, such as: minimal lot size, building setbacks, maximum building rate, land use coefficient, maximum building height, and terrain quota by habitation per unit, lot's permeability rate, and so one. The software City Engine (ESRI) has already a group of rules to make possible the construction of streets, blocks and cities morphologies, but we still have to built the rules (in Python language) to simulate the buildings according to urban parameters and, what is more important, according to the way that an urban designer thinks. This gap between what is available and what is needed occurs because the software was first planned to games, and the logic of an urban planner follows another way of thinking.

At the Geoprocessing Laboratory from the School of Architecture at the Federal University of Minas Gerais is being developing a PhD's thesis based on the construction of these rules to make possible to simulate urban landscape according to Parametric Modeling of Territory Occupation.

3. RESULTS

3.1. Regional Scale Results

The zoning or the typologies of analysis produced by the matrix of combination is very simple, and it has to be very simple, because the objective is just to identify the potentials, restrictions and conflicts on territory occupation, transformation, preservation and development (Figure 3). As it is very simple, with few typologies, it is easier to be understood by the local governments, by the municipalities. Been quite clear to understand, it is a general reference that doesn't interfere in the local specificities. So, each municipality can propose its own way of using the territory, but considering the general limits according to a common point of view.

The areas with clear vocation for the urban occupation and expansion constitute a significant spot, and the observation of their morphology is a way to identify areas of probable growth and to plan the interests of connection and to of these axis, especially with the use of areas with potential for change.

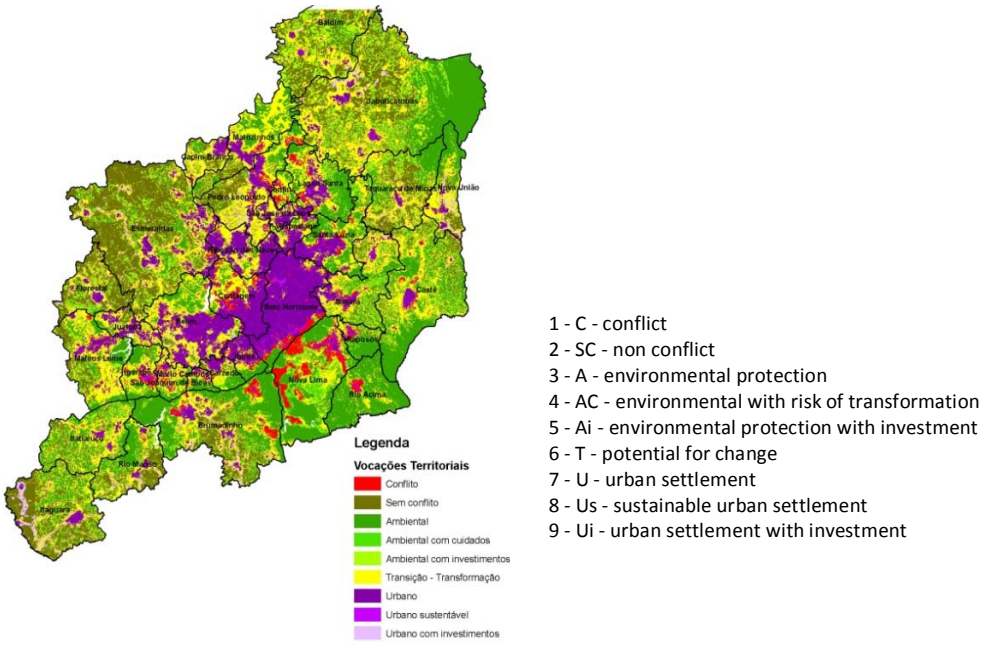
The municipalities that present areas without conflict of interest are identified. With negotiations, they may receive investments for the installation of activities of collective interest, as sanitary landfills, industrial parks, among others. In the same way, it identifies the municipalities of expressive environmental interest, which should be encouraged to protect important natural heritage, also through compensatory actions by be the preservation of collective interest.

Areas of conflict of interest are identified, with emphasis on some municipalities that are clearly problematic in relation to this aspect. There are municipalities that are characterized as areas of expansion of the Metropolitan Region but, at the same time, are holders of significant environmental values. The planner must give attention to spatial areas with potential for transformation, as they are where he can propose actions that will generate effects of irradiation of results in the territory.

Individually, each municipality can be understood according to its specific features, but it is important that decisions should be of collective interest, even with the support for the policies orchestrated so that the expected individual development is not frustrated.

It highlights, in particular, the significant role of this territorial diagnostic for the definition of a macro-zoning, which can serve as initial parameter for the detailing of the Municipal Master Plans, without conflict of interest in the zoning of borders between municipalities, or conflicts of interest between the municipal proposition and the collective objectives in regional scale.

Figure 3 – Map of conflicts of interests, vocations and possibilities

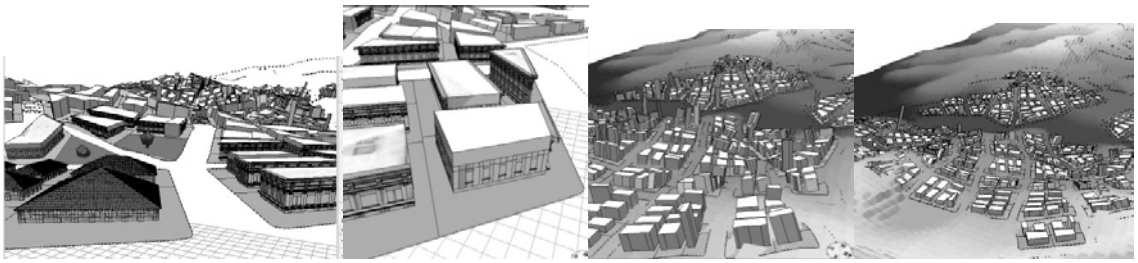


3.2. Local Scale Results

The main goal of investments made towards geo-technologies is the increase of communication with local communities, hoping to make the results of Municipal Development Plans and Urban Occupancy and Zoning Laws comprehensible. This allows the community to place themselves as fundamental agents in the production of their own urban space. And as for the Urban Planner and Architect under formation, our expectation is that they will act in a more conscious manner when creating their projects, undertaking predictive studies on the landscape, since, only then, they are fully able to understand the consequences of their intervention on urban spaces.

The applications available today, like the software City Engine (ESRI), are not yet fully ready to be used in urban planning, since they were originally created for use in games, and there is still a long and demanding work to decode the thinking of urban regulations for the simulation in augmented reality, and promotion of its variations in real time. The GIS Lab team at the School of Architecture from the Federal University of Minas Gerais is committed to building scripts that translate the rules of composition of the landscape, from zoning tables and their parameters. (Figure 4). Our expectation is that after this important step of programming and modeling work, there will be a basis for supporting municipal governments and community control and management of the urban landscape, with a view to promote, in fact, designed spaces within the parameters of sustainability.

Figure 4 – Urban Parameters – Results of Rules in Parametric Modeling of Territorial Occupation



4. CONCLUSIONS

The organized information, with accuracy and available, it's a strategic resource and is essential to take appropriate decisions and in a timely manner. The geoprocessing is an important management tool, because it is a set of technologies for information processing, indispensable for spatial analysis. The use of techniques of geoprocessing helps to deals with complexity, as explains Tomlin (1990) the descriptions about "what" can be expressed in terms of comments-pattern, and more complicated measurements can be done by specific interpretations based on "how".

A great challenge of the technology applied to urban planning is the development of techniques and methodologies that are capable of adequately representing dynamic variables and create future scenarios of possible conformation of the city, for definitions of best strategies and decision making. In addition to the possibility of the combination of variables, the GIS stands out by the possibility of application and construction of models, this means the identification and representation of the logics that reflected the occurrences and the territorial dynamics.

With the new conditions of communicability, visualization, storage and sharing of information; the processes of modeling of the urban landscape and architectural design, begins the time of drawing by definition of parameters, as advocates Schumacher (2008) which explains why the act of parameterization is the new style after the modernism, while post-modernism and the deconstructivism episodes were premature and transient.

We defend that we are already experiencing a new paradigm in planning and designing the urban territory. We can't deny the influence of technical change in the new way of designing architectural and urban areas, and this significant change, which comes to a few large centers, defines the new era. The new technologies of information, the expansion of the conditions of participation of the community, the development of geo-technologies and the integration of functions of GIS

(Geographic Information System) and BIM (Building Infrastructure Modeling) create the foundations for change the way of thinking and shaping the urban territory.

From a legal point of view, it's acceptable and desirable that each territorial unit of occupation can receive its volume conditioning by calculations of its own conditions and the conditions of its context. This means that even within the same zoning or the same settlement of occupation, it is not mandatory that all lots have to fulfill the same coefficients and occupancy rates, the same setbacks, the same heights. Within a region, and observed the capacities, potentialities and restrictions of each sector, each individual unit can have its parameters differentiated, in accordance with the principle of searching for a dynamic balance of the whole.

What changes is that while the zoning provided parameters such as "vested rights" and uniform permission for all the units of its territory, in the new way of thinking the individual right is limited by the balance of the whole, and each unit can obtain individual response on their conditions to the use and occupation. Thus, it is possible to give different answers to different owners regarding the possibilities related to his property, without this been understood as retrenchment of law, but rather as search for balance in the occupation as a whole.

The text presents as conclusion the indication of contemporary values, which are: interoperability between systems, investment in visualization technology, integration of the community in volunteered mapping and, above all, methodological processes based on Parametric Modeling of Territory Occupation.

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