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Planning Support Tools: Policy Analysis, Implementation and Evaluation

Proceedings of the Seventh International Conference on Informatics and Urban and Regional Planning INPUT 2012

edited by Michele Campagna, Andrea De Montis, Federica Isola, Sabrina Lai, Cheti Pira, Corrado Zoppi

Scientific Committee:

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Geoprocessing, Multi-criteria Analysis, conflict of interest and simulation of landscape intervention: learning topics in urban planning, at UFMG – Brazil

by Ana Clara Mourão Moura[1]

The article reports the experience of training students of Architecture and Urbanism, Federal University of Minas Gerais in the use of geo-technologies to support the analysis, planning and proposal of the urban landscape. Presents a case study of urban planning at neighborhood scale, an area with significant spatial complexity due to being the axis of urban expansion and the target of speculation, while it still holds remarkable landscape and environmental resources of great value. Students learn about procedures for GIS and digital processing of satellite images. Apply spatial analysis models, particularly Multi Criteria Analysis for identification of potential and conflicts of interest in land use. The principles of perception and spatial cognition enable students to represent the area's image and vocation. The geo-technologies and the three-dimensional representation of the territory is used to support the proposed zoning and urban parameters indicated by the students to conform the designed landscape.

Introduction. Teaching geoprocessing in urban planning

Recently, a new Architecture and Urbanism night course was created at the *Escola de Arquitetura, Universidade Federal de Minas Gerais* (Architecture School at the Federal University of Minas Gerais). Since it emphasizes urban planning, it differs from the daily course, which has a focus on building project. This new emphasis makes fundamental that students familiarize themselves with geoprocessing tools, in order to acquire abilities that will make them able to: present their planning in a georeferenced man-

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ner, use satellite images, treat images with digital processing for territorial and urban planning, explore resources from Geographic Information Systems and, specially, develop analyses and representation models for urban spaces.

As an example of the course's goals, we present the experience of the thought module "Urban Planning Workshop: Local Planning Problems", discussing issues to a district scale. The students were involved in gathering primary data, examining the data regarding its spatial components, and afterward proposing a settlement type that would model urban landscape in a sustainable manner, respectful to community values and to the environment. Geoprocessing is a fundamental tool in mapping territorial characteristics and investigating conflicts of interest within a specific area, using multi-criteria analyses.

This module holds as pedagogical aims: the construction of a conceptual base for studies on landscape, environment, planning, and spatial perception; training on survey activities; storage, treatment, and representation of spatial data; tuition on spatial analyses methodology; diagnostics, prognostics and propositions of spatial intervention, with the use of geoprocessing; and, finally, the study of public policies and legislations regimenting urban settlements, regarding their contexts.

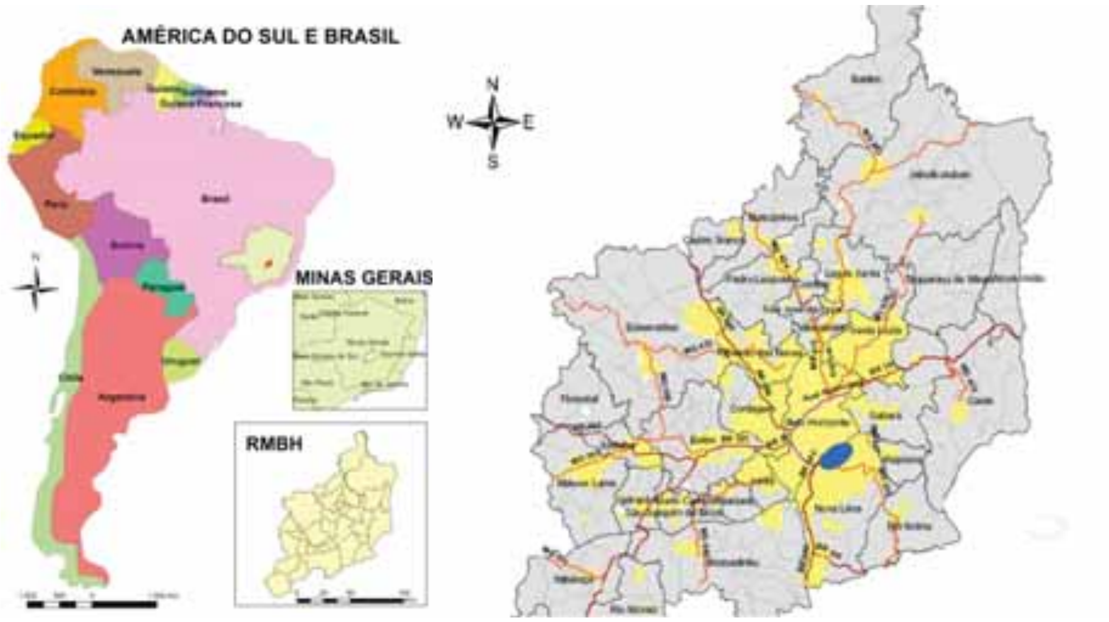


Fig. 1 – Metropolitan Region of Belo Horizonte and the "Vale do Sereno" district Locations.

We picked the Vale do Sereno district, which is located in a frontier area between two municipalities: the Minas Gerais state capital municipality, Belo Horizonte, and the Nova Lima municipality (Fig. 1). The district is still not densely populated, but it suffers from an expressive pressure for urban transformation and growth, and it is being heavily impacted by vertical growth and by the settlement rate, despite its conflicting principles to environmental interest and to the preservation of what is a notable landscape. Reasons for this growth reside in its being the most economically interesting region for selling real estate within the Metropolitan Region (Região Metropolitana – RMBH) of Belo Horizonte, and since urban regulations (presented at the development plan of Nova Lima) authorize this intense growth and transformation on the urban landscape (Fig. 2).

This study was undertaken using Multi-criteria Analyses, spatial perception research, and proposition of a settlement typology, which considers existing conflicts and local landscape context. The students were instructed to use geotechnologies as a support tool for visualizing and communicating their urban intervention proposals, also simulating their effects on the resulting landscape.

Fig. 2 – "Vale do Sereno" Landscape – expressive settlement growth.

Methodology for urban planning, supported by geoprocessing – Multi-criteria Analyses and Decision Tree

Geoprocessing is an important tool for supporting decision making processes. Regarding its applicability, Moura (2007, p. 2899) states:

> Instead of simply describing elements and facts, models for spatial analyses using GIS can describe scenarios and simulate phenomena, basing on observed tendencies or considerations on pre-established conditions. GIS is used also to select analyses variables and in the study of their combinations. These are attempts to represent reality in a simpler manner, selecting the most relevant aspects, and seeking information on correlations and behavior expressed by environmental variables.

With the aim of making maps *Environmental Interest Synthesis* and *Urban Expansion Interest Synthesis*, different variables where selected for each. Variables were mapped initially as ordinary themed maps, which were later turned into potential surfaces for the theme's distribution, according to their relevance for each of the syntheses. A Decision Tree is built as a flowchart combining variables through map algebra. In this specific work, the algebra used was pondered average, by giving weights for combined variables and grades for their legend components.

In order to allocate weights, which demonstrate the relative importance of each variable to the analyses, we chose to undergo a consultation, aiming to obtain an opinion average, for maximizing the consensus using the *Delphi* method. The process was organized in the following manner: the students gave their individual opinions on the hierarchical position of each analyses variable. After the gathering of opinions, we presented the opinion average and mode to the group, and each individual gave out a second opinion, altering or not their first one. Then, a new medium was calculated, being then used as a reference for the variable's weights. This process is known as "knowledge driven evaluation", meaning the incorporation of opinions gave out by informed people regarding the situation under evaluation, about specific aspects of the phenomena and their variables. The students, since they participated in field work and interviews with locals, had knowledge on the factors interfering in the area's characteristics. It is considered that "the specialists view is calibrated" and, also, that statistically speaking, the higher the number of variables, the smaller will be the probability of a random result, since fluctuation decreases.

Moura (2007, p. 2902) explains the logic within variable combination:

> The application of Pondered average creates a classificatory space, ordinal, which may also be understood as an interval scale. This process may also be used in a nominal scale, since events are inserted into a hierarchy according to a value criterion. Pondering must be used by 'knowledge driven evaluation', meaning, inclusion of opinions expressed by informed people on phenomena and variables, or by 'data-driven evaluation', which refers to previous knowledge of similar situations. In this process, the possibility of pondering a situation inadequately is the reverse of the number of attributed pondering.

Grades, in turn, are values attributed to each legend component within themed maps, defined according to the relevance degree each variable/occurrence holds, and regarding a specific goal. In the case of the Need for Environmental Protection synthesis, grades meant how much each spatial occurrence is important for preservation. As for the Expansion Interest and Urban Density Synthesis, grades attributed show how much each spatial occurrence is adequate for population density and settlement.

Once partial Need for Environmental Protection synthesis and Expansion Interest and Urban Density Synthesis are created, it is beneficial for the urban planner to compare the analyses, in a way to identify potential transformations, conflicts of interest, and new land use possibilities.

Decision Trees with variable weights employed are presented in Fig. 3.

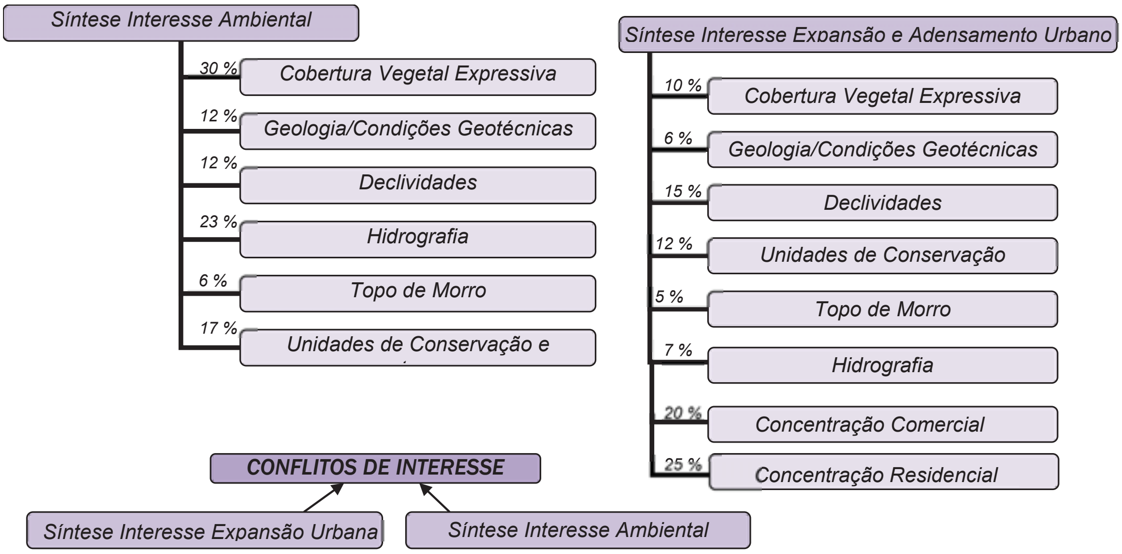


Fig. 3 – Decision Tree for structuring Environmental Interest Synthesis, Expansion Interest and Urban Density Synthesis, and Conflicts of interest Synthesis.

Spatial analysis – Results and discussions

Information layers of each analysis goal were generated for identifying environmental and urban expansion interests. Each layer was transformed into a potential surface for specific variable distribution, according to their importance for each analysis' goal. These layers were then combined by multi-criteria analysis, which generated partial syntheses. This, in turn, allowed for the identification of possibilities and conflicts of interest.

Environmental interest synthesis

Through the same procedure used for urban expansion interest synthesis, an environmental interest synthesis was generated. The variables which are most decisive in environmental condition interests were identified, and information plans were created for each variable:

a) *Vegetation cover*. Map obtained through orthophotograph classification. The area presents a rich vegetation cover. The classification credited a grade 10 for areas with vegetation cover and 0 for areas without it.

b) *Geology/geotechnical conditions*. A study was developed using considering adequateness to urban settlement and the need for protection due to settlement risks as criteria.

c) *Declivity*. Based on Digital Elevation Model of Aster images, and classified by bands of 0 to 5%, 5 to 30%, 30 to 47%, and above 47%. Declivities above 47% are considered to present higher preservation interest, followed by declivities of 30 to 47%, while low declivity areas are more subject to flooding. Declivity bands of 5 to 30% are not an environmental priority, according to the approach using this variable.

d) *Hydrography*. Its map was created from the location and attribution of water bodies' control bands.

e) *Hilltop*. Hilltops, represented on the altimetry by the last third sub-basin, are considered environmental protection areas and restricted for settlement.

f) *Conservation units*. The area studied is located near two conservation units: an Ecological Station and a RPPP (Permanent Private Patrimony Reserve). The last is an environmental passive held by a mining company and the ecological station protects water abstraction areas for the surroundings consumption.

g) *Environmental interest synthesis map*. Once maps were created, they underwent through a multi-criteria analyses, according to values defined by specialists, using the Delphi method. The weights attributed for each layer were: Hydrography, 23%; Conservation Units and their surroundings, 17%; Geology/Geotechnical Conditions, 12%; Expressive Vegetation Cover, 30%; Hilltop, 6%; Declivities, 12%. (Fig. 4).

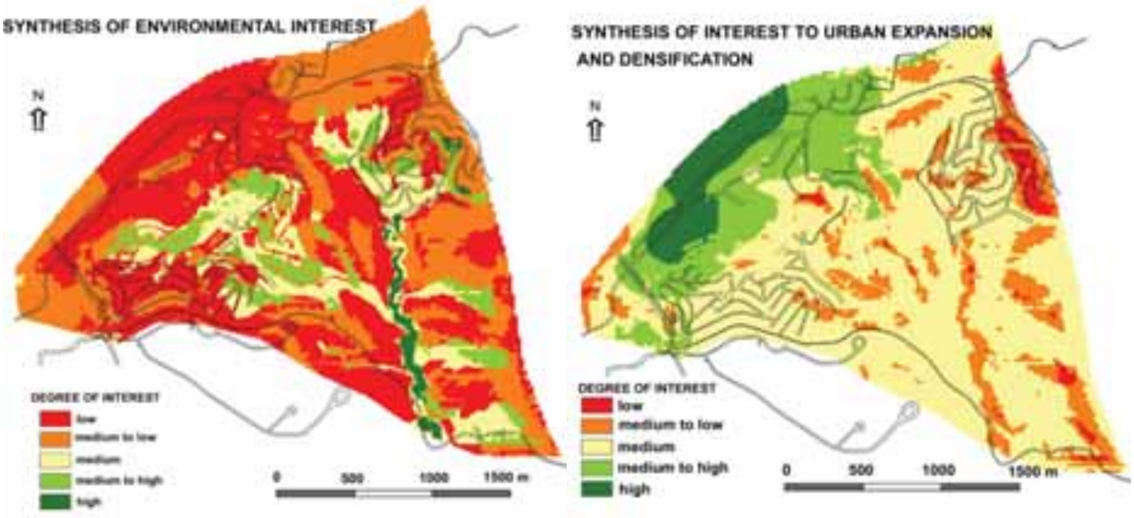


Fig. 4 – Need for environmental protection synthesis & urban expansion interest synthesis.

Expansion interest and urban density synthesis

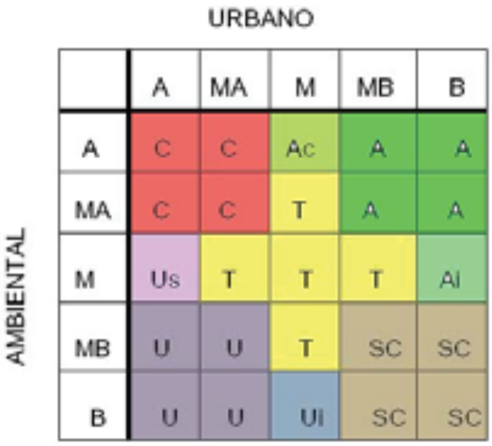
Spatial analysis procedure identified variables which are most decisive in urban settlement interest, and promoted the creation of information plans of each variable. Information layers were translated through matrixes, with 10 meters resolution and legend values meaning the relevance degree, graded from 0 to 10.

a) *Vegetation cover*. Map obtained through orthophotograph classification. We observe that an expressive vegetation cover is understood and classified as an impeding factor to urban interest.
b) *Geology/Geotechnical Conditions*. A study was developed using considering adequateness to urban settlement.
c) *Declivity*. Created from the digital elevation model of Aster images, and classified by bands of 0 to 5%, 5 to 30%, 30 to 47%, and above 47%. Settlement conditions were evaluated regarding flood risks, without risk, medium risk not suitable for building.
d) *Residential density*. From points of residential land use, Kernel's density model was used, and different degrees of this type of settlement were defined in bands. Considering that there is a greater interest in living in already consolidated settlement areas, we used the distance from these settlement clusters as criteria for this band grading.
e) *Commerce and services cluster*. From points of commerce and services clusters, Kernel's density model was used, and different degrees of this type of settlement were defined in bands. Considering that there is a greater interest in living in areas providing commerce and services, we used the distance from these settlement clusters as criteria for this band grading.
f) *Conservation units*. The RPPP (Permanent Private Patrimony Reserve) and the EE (Ecological Station) were considered with restrictions to settlement.
g) *Hydrography*. For water courses and their head are areas of permanent protection (APPs) and may not comprise a settlement.
h) *Hilltop*. Hilltops, represented on the altimetry by the last third sub-basin, are considered environmental protection areas and restricted for settlement.
i) *Urban expansion interest syntheses map*. Once the maps were created, they underwent through a multi-criteria analyses, according to values defined by specialists, using the Delphi method. The weights attributed for each layer were: Hydrography, 7%; Conservation Units and their surroundings, 12%, Geology/Geotechnical Conditions, 6%; Expressive Vegetation Cover, 10%, Hilltop, 5%, Declivities, 12%, Residential

Cluster, 25%, and Commerce and Services Cluster, 20% (Fig. 4).

Identification of potentials and conflicts of interest

Once the syntheses for urban expansion interest and for environmental interest were created, they were compared in order to promote the identification of areas where settlement potential is clearly defined, where there are conflicts of interest, as well as were there are specific conditions of interests and potentials.



C - conflict
U - urban settlement
A - environmental protection
SC - non conflict
Us - sustainable urban settlement
Ai - environmental protection with investment
Ui - urban settlement with investment
T - potential for change

Fig. 5 – Combination Matrix Conflicting Interests, Urban & Environmental Interests.

The logic used in this analysis is also matrix analysis developed by Moura (2005), for which possible combinations are identified (Fig. 5), and the results obtained (Fig. 6).

It is observed that there are combinations with clear interest predominance, either environmental or urban settlements. In opposed conditions, there are areas presenting medium to high interest, both environmental and urban, generating conflicts. On the other hand, there are also areas of no conflict, presenting medium to low urban or environmental interests. Decisions regarding conflict areas are left to be resolved within politics, or by clear definition of interest priorities, what can be widely justified and discussed. Areas presenting no conflicts of interest are indicated to be utilized for other needed uses, potentially generating conflict if located in other areas, such as land fillings, industrial parks, recycling stations, etc..

There are regions where there is a medium interest in environmental preservation and low urban interest, which defines them as environmentally interesting, but with need for recuperation investments. Also, there are regions where there are regions where there is high environmental interest and medium urban interest, which defines them as environmentally interesting, but monitoring and maintenance are needed, since there is some degree of urban interest and consequent pressure.

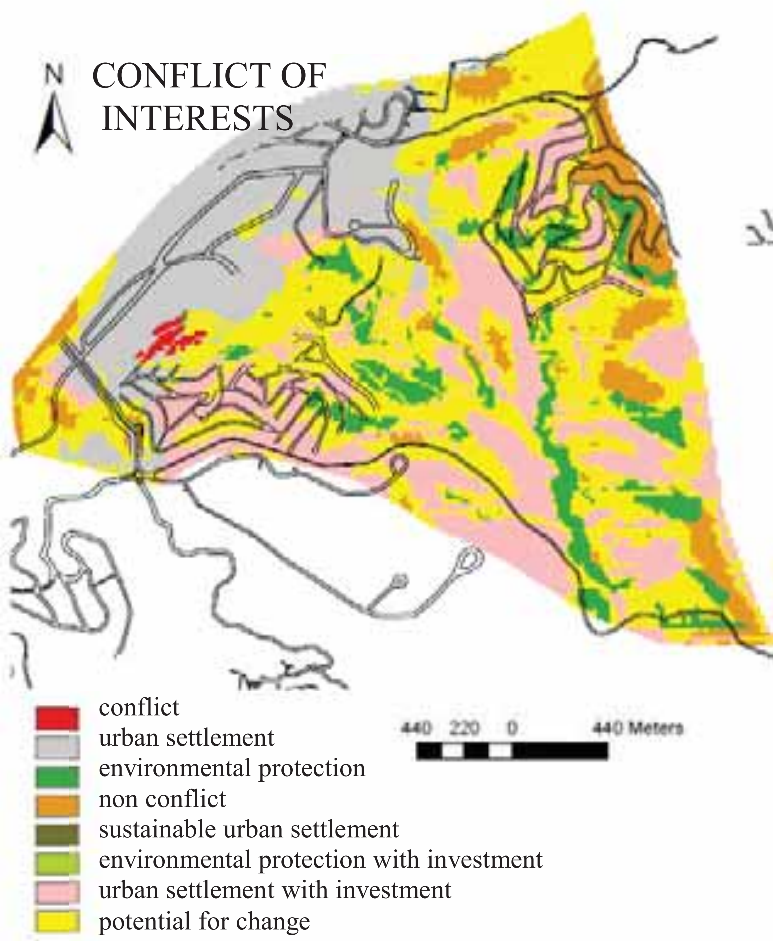


Fig. 6 – Mapping of Conflicts, Possibilities and Potentials.

On the other hand, there are regions presenting medium urban interest and low environmental interest, what defines them as presenting an urban interest, but still with the need for investments to make them properly attractive. There are also regions presenting high urban interest and medium environmental interest, what defines them as urban interested regions, but still of sustainable use, once environmental issues still must be considered. These areas present potential for being Environmentally Protected Areas (*Áreas de Proteção Ambiental* – ASPAs).

In cases where an area presents medium interests for both urban settlements and environmental preservation, they are classified as transitional or as having transformation potential. They are significantly interesting for territorial planning, since when transformed they do not generate conflicts, but possibly generate irradiating results.

Studies on landscape perception as an assistance tool for image planning

Once the area is characterized according to their potentials, restrictions, possibilities and conflicts of interest, we moved on to the next step. Landscape perception interpretation and representation was undertaken, according to Spatial Perception and Cognition theory. The goal was to lay a foundation for the following phase, which was a project for land use and projection of the resulting new landscape for the district. This stage aimed to understand not only values involved, not only from the technical point of view, but also regarding landscape identity values.

As theoretical bases, classical authors were discussed, such as Kevin Lynch (1997), with *The image of the city*, and Gordon Cullen (1983), with *Urban landscape*. Lynch's readings gave helped them perceive place through their structuring elements, mental map creation, legibility conditions, landscape identity and singularity. Cullen's readings instigated 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 facilitated them to identify the district's *genius loci,* what characterizes its landscape, what is valued by the community, and must be considered by urban projects.

In order to students benefit the most, we used field work, interviews with the community, and the making of expressive images, both by hand drawings and digitally altered photographs, capturing the landscape's place essence (Fig. 7).

Fig. 7 – Drawings representing landscape's essence.

Conclusions. Urban zoning proposals

The drawing and landscape perception field step was important to slow down the time spent in observing and apprehending landscape, while the students understood their main characteristics and values, they could also mature their reflections on their urban zoning proposals.

The project proposals again face them with geotechnologies, since we required from them that all processes were undertaken in tridimensional representations, in a way they could have control over their project proposals, develop more effective forms of communication to locals, and simulate their results for prediction studies.

The students presented, as final products, maps specifying the zoning proposed for the district, justifying each settlement type, regarding previous analyses. Along with this map, they also made tables presenting urbanistic parameters indicated for each zone, such as: minimal plot size, building setbacks, maximum building rate, land use coefficient, maximum building height, terrain quota by habitation unit, plot's permeability rate, etc.. In order for them to control their propositions, we asked them to attach tridimensional simulation drawings to the tables, so that they would really understand the meaning of those values, within a prognostic study of landscape intervention (Fig. 8).

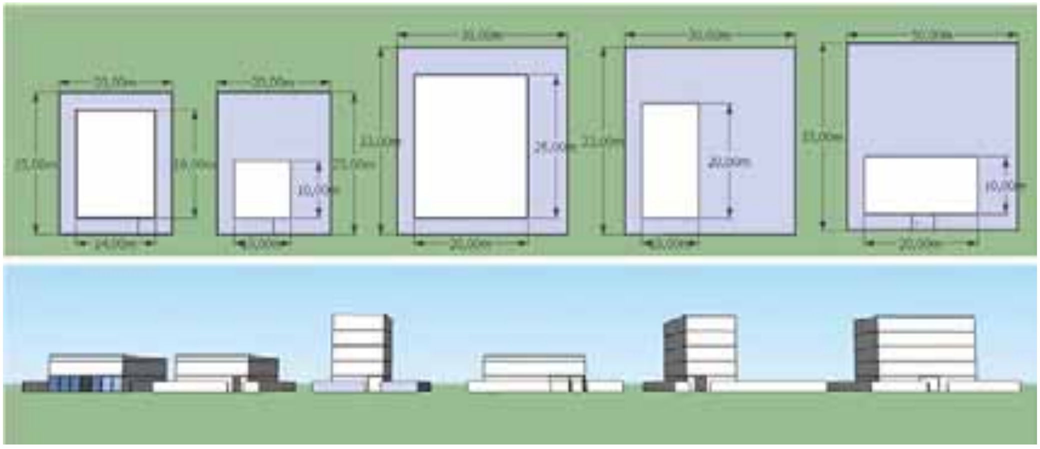


Fig. 8 – Urbanistic Parameters. Simulation of landscape intervention.

Fig. 9 – Tridimensional representation of the landscape and prognostic for the projected landscape.