When the parametric modeling reveals a collapse in the future urban landscape: The case of Divinópolis – Minas Gerais/Brazil

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Introduction

This article discusses issues related to the urban environment and landscape planning in the county of Divinópolis, Minas Gerais, Brazil, focusing on the central area of the city. The main proposed approach the theme is the study of the mechanisms of the master Plans as generators and catalysts of landscape transformations, in order to carry out simulations that allow an insight into the future trends and analyze the feasible developed landscapes in a critical manner according to the current legislation (Villaça, 1999).

The City Hall of Divinópolis, in partnership with FUNEDI - Foundation of Education in Divinópolis (2013), made the diagnosis for the elaboration of the local Master Plan, which demonstrates the relevance of geoprocessing tools to urban planning processes, and also foments civic discussions regarding the common decisions.

The justification of this article relates to a law in Brazil (City Statute, 2001), where the Federal Government pressured the states and municipalities to take a leading role towards control and management of urban and regional planning processes. Based on this, the City Council of Divinópolis approved the new *Participative Master Plan* and established new tools for urban planning, in 2014.

The main purpose of this article is to analyze the effects of zoning and urban parameters in the composition of the urban landscape in the central area of Divinópolis through three-dimensional scenarios designed with geoinformation technology. The main issue is that the parameters and zonings are approved without a visualization support before the final decision, as absolute and morphometric values, without simulating the future of the landscape, which would be an important step in the process of decision making.

Methodology

A methodological guide is proposed that includes the following steps: 1) survey and spatial data; 2) analysis of past and current legislation; 3) modeling and analysis.

According to Moura (2007), the spatial analysis methodology, based on crossing plans information, begins with the assembly of the database and specialization in georeferenced maps. The composition of systematized themes in the form of information systems is the base of modeling and it intends to simplify representation of reality to reach specific purposes of the analysis. Thus, the indication of main variables is an important step in the research, and will require specific technical procedures regarding processing and visualization.

Survey and spatial data

Divinópolis is a county of Minas Gerais, Midwestern region polo of the State, located in the metallurgical area, micro-region of Itapecerica Valley, crossed by Itapecerica and Pará rivers, and 121 km away from the capital. According to the census in 2010, conducted by the Brazilian Institute of Geography and Statistics (IBGE), the county has an area of 708.909 km², and 226.345 inhabitants, with a density of 319.29 inhabitants/km². (Wikipedia website, accessed in 07/04/2015).

Fig. 1. Location and landscape photo of the study area (source: C. Lima, Flicker).

Various processes were needed to collect and process data of the study area, such as collecting, georeferencing and vectorization of historical maps, and the survey of historical iconography to identify outstanding values. The data were selected at the central archive collection of the county, and in consultation with the county´s domain sites (Ferreira, 2015). The final vector map representing the history of the territory occupation, despite the low cartographic precision, creates a database for understanding the evolution of the settlement, and this product is the basis for the visualization of the occupation dynamics.

The field study occurs in two different approaches for data collection, through virtual visit with Google Earth software and field visit, in respect to the volumetric of the buildings, the type of use, the locals of establishments and great equipments, as well as the characterization of the general conditions of the city and especially the central area. There are six types of buildings: private residence, commercial, mixed-use, education unit, health unit and public use.

The data were georeferenced on the municipal cadastral map of the city, using polygons of buildings and blocks as univocal references. The result of the registration is the creation of a base with typologies of activities, which enabled the development of spatial distribution of density maps by category of land use, and a map of the general density of commerce activities, services and collective use services to the identification of the county´s centralities, based on kernel density (Saboya, 2008; Rocha et al, 2011; Guadalupe and Moura, 2014). The Purpose of the map is to demonstrate the extreme dependence that the city still has towards its central urban area, but at the same time to identify centralities that starts to configure themselves as local references

at the periphery areas, and that could be empowered by the Master Plan concerning the decentralization and diversity of activities. (Figure 2).

In order to analyze the risk of losing urban values, since the central urban area is the main centrality but also the main place for historical and heritage values, a representation of the local landscape based on a map from 1922 was elaborated. To this 2d first map it was added the information about 3D values using the height of the buildings obtained in the study of historical iconography as a reference. The architectural elements that tell the history of the place are those who keep the essential values to the citizens. It justifies the study of the landscape transformations throughout time, and its impact towards the most symbolic elements on the landscape (Figure 3).
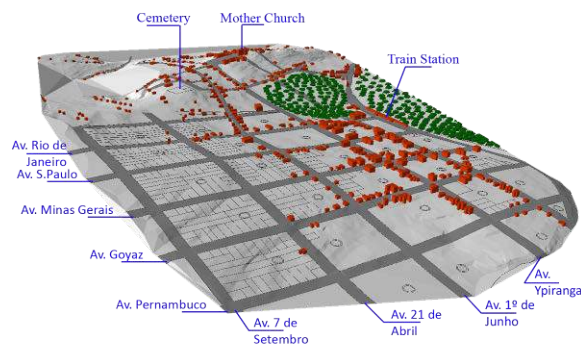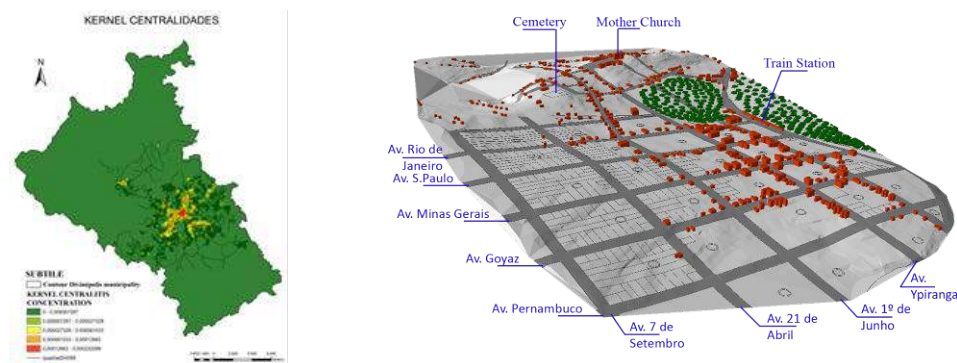

Fig. 2. Kernel Centralities - Fig. 3. Representation of Divinópolis city in 1922.

Analysis of past and current legislation

The Master Plans of 2000 and 2014 were studied, the last one being approved by citizens' participation. They were prepared spreadsheets with urban parameters of master plans and performing mathematical formulas to understand the requirements for the use of law and land use in order to understand how the parameters affect the approved projects and result in the built landscape in the city. In addition to this study, several people were interviewed for us to see if they were able to understand the meaning of the parameters and their values, which were approved in public sessions of the Master Plan process. The results favored the comprehension of the project´s approval dynamics and the difficulties that citizens (even technicians) have to visualize the urban parameters.

Modeling and analysis

Once the database was structured, the mathematical and geometrical rules that define volumetric composition of the city under actual legislation, a digital modeling and three-dimensional representation (ArcGis and ArcScene) were performed. The Digital Terrain Model (DTM) was elaborated and, above it, the buildings volumetric representation. The goal was to recognize the influence of urban parameters in the production of urban landscape, creating critical bases to review those parameters or to propose new ones (Figure 4).

Results and discussion

There were two tridimensional representations produced: the already existing volumetric landscape and the possible volumetric landscape according to the maximum parameters authorizations contained in the actual legislation (Master Plan).

The comparison between the two scenarios shows how current laws are permissive, allowing in its normative: 1) the verticalization (increase of high-rise buildings), 2) the largest volumetric occupation, and 3) the significant increase in population density on an infrastructure already saturated. It is a space that already suffers from urban problems such as population growth and chaotic traffic, and should be subjected to a better management, mainly because the city presents significant elements for the image of the region, including the intangible ones such as the feelings of belonging of the territory.
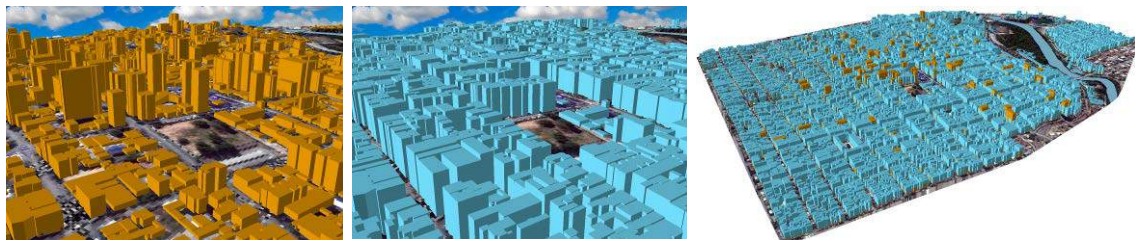

Fig. 4. Urban landscape in 2015 - Fig. 5. Urban landscape of Divinópolis if all the parametric are on its maximum – Fig. 6: Comparison between the Fig. 4 and Fig. 5.

The digital modelling of urban landscape image, considering the authorized parameters proposed by current laws (Figure 5) is a base to begin a critic analysis about how catastrophic the application of current legislation could become, regarding the construction and modification of urban landscape. The comparison between the two scenarios, already constructed and authorized to be constructed, shows that the actual rules favors expansion throughout the area, as that the maximum authorized parameters stands out in relation to actual built ones, what means a tendency of volumetric expansion. The comparison also allows identifying the points where the growth has been so significant that buildings rise above an acceptable maximum. (Figure 6). The result of this analysis based on digital tridimensional simulation is that urban center, which already presents problems related to limitations in infrastructure and loss of cultural and historical values, runs the risk of having these problems magnified.

The current legislation is permissive, allowing in its rules the verticalization and the expansion processes tensioning the existing infrastructure. The area, which already suffers from urban problems linked to population growth and overload in traffic, can also lose the essence of the city's image. The average height of the buildings, which is currently 4.7 meters, could become 25.42 meters (8 to 9 floors). This verticalization tendency is accompanied by total waterproofing the surfaces of lots, since the law allows a 100% occupation of the garage and first floor´s level. The situation is even worst in buildings intended for use exclusively commercial, because in these cases it is allowed to build in 100% of the lot, without setbacks.

Conclusions

Jane Jacobs proposes the comprehension of the city from the following angles: 1) reflect on the processes; 2) use of induction, reasoning from the particular to the generic, rather than the reverse; 3) look for evidence in which little things lead to bigger things. According to her

proposal, processes that take place in cities are not mysterious, as they can be understood not only by experts but also by almost everyone. (Jacobs, 2011).

Based on bibliographical review, data collection and the models analysis, it is evident that urban rules which are regulating the constructions in Divinópolis are outdated, permissive and harmful to the city. The analysis of the historical evolution reveals that, except in some mandates of urban management, the municipal government never bothered about urban landscape changing, which could happen with at least a more appropriate application of urban parameters. This phenomenon, unfortunately, doesn't happen only in Divinópolis, but almost in all medium and large cities in Brazil. Almost nothing is proposed to preserve the identities of cities that are not on the list of recognized heritage or/and considered national or international cultural heritage. The Master Plans goes towards the interests of the real estate market.

The purpose of elaborating a parametric model is to help citizens visualize the constructed and the authorized urban landscape, as well as giving support to decision making, since the urban planner acts as a mediator to decode citizens' values to be respected by government technicians. Therefore, it is fundamental to produce methodologies to encourage the interest concerning to the city's landscape planning, in order, for example, to decrease informal occupation, that in Brazil represents the majority of urban construction.

The parametric model and its analysis reveal that urban laws in Divinópolis don't take in consideration historical and cultural values and also don't consider the limits of infrastructure capacity and don't care about environmental values. Parameters related to visual axis, index of insolation, floor area ratio to allow soil impermeabilities, and urban volumetric limits to allow overuse of the central area according are not proposed in the Master Plan. According to the studies of urban growth and the identification of actual centralities, we can observe that Divinópolis is the transition from mononuclear city to polynuclear city, and the Master Plan could support this tendency to avoid the concentration in the main center.

The next step in the investigations will be to propose and simulate the results of new urban parameters. The citizens' participation to discuss and chose alternative futures to the landscape can be based on the framework for Geodesign (Steinitz, 2012), which aims to design "for" and "with" the landscape, on an integrated and balanced way, as well as promoting visualization to social actors and performing revisions and adjustments whenever necessary. As a contribution to the state of art, this study presents a first step to give support to the review and the adjustment of the Master Plan, step that is already planned to be held in the Participative Master Plan of Divinópolis.

Acknowledgements

References

Ferreira, Eliseu. 2015. "História Cronológica de Divinópolis". http://www.adletras.com.br/index.asp?c=paginas&modulo=informativo_exibe&url=252&navegacao_ca

tegoria=Publica%E7%F5es&navegacao_subcategoria=Elizeu%20Ferreira#barra. Accessed March 19

FUNED-UENG. 2013. *A configuração territorial de Divinópolis: Plano Diretor Participativo de Divinópolis*. 262 p.

Guadalupe, Diogo, Moura, Ana Clara. 2014. "The Model of Voronoi's Polygons and Density: Diagnosis of Spatial Distribution of Education Services of EJA in Divinópolis, Minas Gerais, Brazil". *Tema: Journal of Land Use, Mobility and Environment*. June p. 271-283.

Jacobs, Jane. 1961. *The Death and Life of Great American Cities*. New York: Randon House Inc.

Moura, Ana Clara M. 2007. Reflexões metodológicas como subsídio para estudos ambientais baseados em Análise Multicritérios. Paper presented at the XIII Simpósio Brasileiro de Sensoriamento Remoto, Florianópolis, Brazil, 21-26, INPE, p. 2899- 2906.

Saboya, Renato. 2008. *Urbanismo e planejamento urbano no Brasil – 1875 a 1992*. http://urbanidades.arq.br/2008/11/urbanismo-e-planejamento-urbano-nobrasil-1875-a-1992.

Rocha, Luciana S., Fernandes, Vivian de O., Brito, Patricia L. 2011. "Análise espacial do estimador de intensidade kernel para as áreas sujeitas a riscos hidrológicos no município de Salvador-BA". Paper presented at the XXV Congreso Brasileiro de Catografia, 2011, Curitiba.

Steinitz, Carl. 2012. *A Framework for Geodesign: Changing Geography by Design*. Redlands, California: Esri Press.

Villaça, Flávio. 1999. "Dilemas do Plano Diretor". In: CEPAM. *O município no século XXI: cenários e perspectivas*. São Paulo: Fundação Prefeito Faria Lima, 237 – 247.