Rozwój Regionalny i Polityka Regionalna 35: 73–87
2016

Camila M. Zyngier, Ana Clara Moura, Rogério Palhares, Flávio Carsalade

Federal University of Minas Gerais, Belo Horizonte, Brazil

Geodesign in Pampulha cultural and heritage urban area: Visualization tools to orchestrate urban growth and dynamic transformations

Abstract: This paper discusses the role of visualization in Geodesign methodology considering its applications in the case study of the region of Pampulha in Belo Horizonte, Minas Gerais, Brazil. In order to consider the opinion of the participants, their efforts were recorded in different steps of the process, at different stages of Geodesign iterations, and different possibilities of visualization were tested. The methodology of Geodesign was applied in different applications and with different tools. The goal was to determine whether different techniques and tools used in the process of Geodesign contributed to improved understanding of data and problem context, and to derive guidelines for improved Geodesign techniques and tools.

Keywords: Participatory planning, Geodesign, Visualization, Urban Growth, Urban Transformation

Introduction

The GIS Laboratory (Geoproea) in the Architecture School of the Federal University of Minas Gerais (EA-UFMG), Brazil, has been engaged in the implementation of Geodesign methodology in case studies of conflicts of territorial interest since 2015, aiming to test the methodology in cases where the construction of a collective understanding is crucial. Geodesign has been shown as a listening mechanism to give support to opinion making. As an opinion making system, Geodesign informs, provokes reflections, fosters different social representations, presents their values and ways of thinking, and enables the orchestration of a common plan.

Case studies conducted by Geoproea were not sponsored by institutions or companies, but academic studies that aimed at students' training. This training has taken place not only in academia (with students and researchers), but it has also included technical staff (from public institutions at federal, state and local levels) and various sectors of society (NGOs, various institutions and social representation groups). The goal is to provide tools to different social groups so that decisions concerning the future of landscapes and scenarios can be truly shared. This means that knowledge about the characteristics, potentialities and limitations of the territory in question must be assembled.

Thus, the main contribution of Geoproea is training, in order to understand the role and the possibilities of building a collective agreement with the participation of different sectors of society. This objective justifies a large investment in the visualization of information, so that there are shared codes that promote the understanding of the process, the existing reality of the responsibilities involved, and the proposals under construction.

This paper discusses the role of visualization in Geodesign methodology in the context of its case study in the area of Pampulha in Belo Horizonte, Minas Gerais. The usability tests applied during the study measured change in visualization effectiveness and were run at different stages of Geodesign iterative process soliciting opinions of the participants and recording their difficulties at each stage. The goal was to determine whether there was an increase in understanding data and case study context and to derive guidelines for improved Geodesign techniques and tools.

Pampulha is the area of interest for the study because it has recently received the status of World Heritage Site by UNESCO (United Nations Educational, Scientific and Cultural Organization) due to the presence of Oscar Niemeyer's work – a modernist set of buildings and surroundings designed in the 1940s (Fig. 1). The title was granted due to the beauty and originality of the architectural work, its insertion into the landscape, and other reasons making Pampulha a unique landscape. The acquisition of the title, the interest in the area, and the importance of alternative futures discussion for this area, provides the rationale for the research presented herein. The Geodesign case study was initiated when the application for Pampulha to become a World Heritage Site was still under discussion. Already at that time the significant growth and transformation of the area and the risk of loss of remarkable values could be observed.

Despite its historical, cultural and environmental values, the Pampulha Regional Administration Area, which includes Oscar Niemeyer's work, presents many conflicts of interest due to environmental and economic interests related to growth and residential density, and social pressures on the land use of area. Much of the Pampulha region offers excellent conditions for infrastructure and urban services and has a landscape not yet transformed by excess of volumetric

Fig. 1. Images of Modernist architecture and local landscape in Pampulha
Source: Ana Clara Moura, Federal University of Minas Gerais, Brazil.

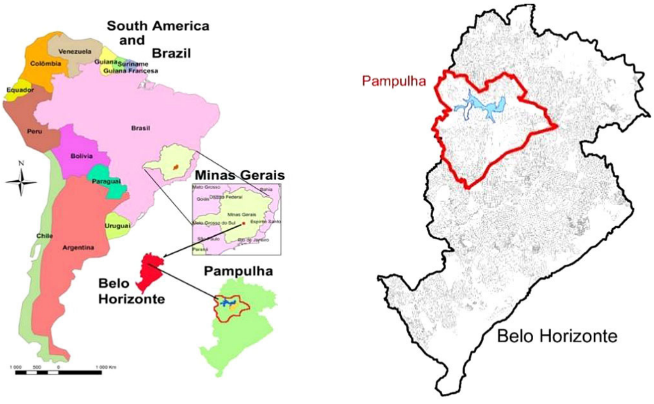

Fig. 2. Pampulha Region
Source: Information Technology Company for the City of Belo Horizonte.

occupation or population density. However, the landscape quality is at risk of transformation, which justifies the present study focus: a territory that is not restricted only to the area of Niemeyer projects, but involves the entire Regional Administration Area (Fig. 2).

The Geodesign, a spatial analysis methodology proposed by Steinitz (2012), is a framework that aims to establish the forms of participation of different stakeholders in the decision making process. To reach decisions, one must first know the main characteristics of the territory being analyzed, its dynamics and needs. Once the problem is known, representative groups of different sectors of society engage in the preparation of proposals addressing both political issues and projects. They have the opportunity to evaluate the impact of their ideas both in terms of costs and also regarding acceptable limits (targets) for territorial transformation. Each group of representatives also has the opportunity to contrast and compare their views and proposals with other groups representing different actors in society, and also to understand their logic and values. Throughout the process consensus maximization is pursued, but it is also important to remember that the absolute consensus does not exist; nevertheless, it is possible to orchestrate a collective decision.

The process of Geodesign presents a framework and a structure with methodological steps and processes. The framework consists of modeling steps aimed at characterization, process analysis, change analysis, calculation of impacts, and adjustments in decision making concerning land use organizations and environmental arrangements. The process is flexible enough to adapt to various territorial and cultural realities, and to design landscape contextualized in local needs (Fig. 3).

Geodesign structures the support for forming opinions and eventually decision-making and can be considered a deployment of a Planning Support System (PSS) (Campagna 2016) with territorial character. It can be argued that the Geodesign process is a geographically-specific PSS based on the methodology developed by Carl Steinitz (Zyngier 2016a; Zyngier 2016b). The Geodesign method-

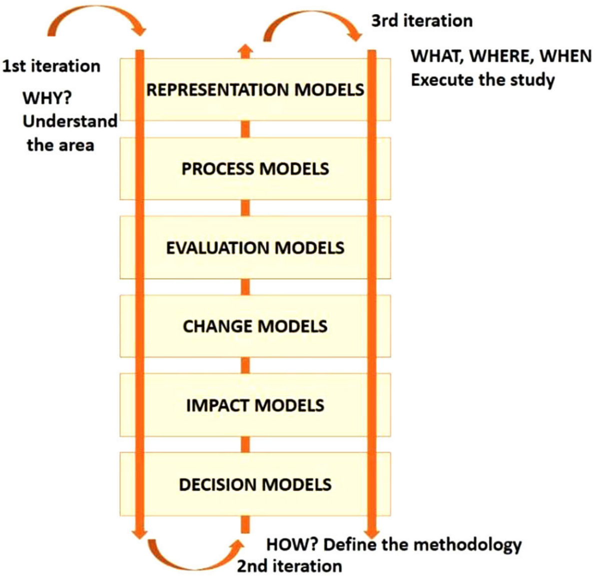

Fig. 3. Iterations and Models in Geodesign
Source: Adapted from Steinitz (2012).

ology, according to Magalhães (2016), provides a non-linear workflow, referring to an open system operation capable of inputs and outputs (information, data). The author points out that this degree of openness allows, for example, the rearrangement of data, changes in the size of the study area, as well as the entry of new data through feedback.

Methodology

This paper illustrates the composition of three Geodesign iterations in the case study of Pampulha, with viewing investment intent in the models employed. Each iteration involves working with representation, process, and evaluation models resulting in the production of data, information, and knowledge respectively. Following the account of the existing conditions, the proposal stage begins, which is related to change, impact and decision models that also produce data, information and knowledge.

The research step is usually drawn up by a technical group that defines one set of 10 systems that accounts for the main features of the study area. These systems are the basis for building diagrams, which are translated into projects and policy proposals for the area. These diagrams are the change models, which are assessed for their potential impacts, so that they will allow the groups to take a collective choice to select the best project proposals and policies.

The Representation Models deliver the first portraits of the area, and explain "how the area can be described", according to main variables. The Process MOD-

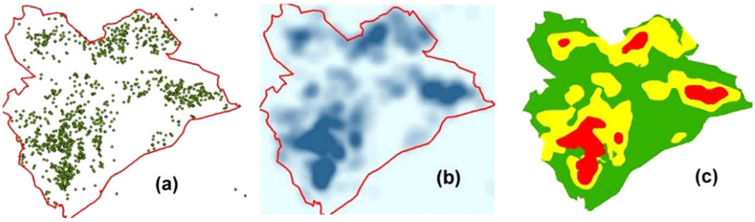

Fig. 4. Example of representation, process and evaluation models of "Dynamic Real Estate" in Pampulha. The Representation Model (a) illustrates each new construction approved in the last five years, the process model (b) illustrates the concentration of new projects, and the evaluation model (c) indicates where it is not necessary to propose new projects (red) and where they may still be proposed (green)
Source: Produced by authors using ArcGIS.

EL explain "how the area works" and are related to surfaces of phenomena distribution in the area. The Evaluation Models demonstrate "if the area is working well" and are the basis for proposing the change diagrams (Fig. 4, 5).

The specification procedure for representation, process, and evaluation models needs to consider some technical aspects to produce sufficiently detailed information so that participants recognize the image they have of the area, but is also sufficiently simplified to avoid aspects irrelevant for planning (Fig. 6).

Some technical rules must be observed in the implementation of the models:

- Simplify Polygons – with the objective of reducing vertices and details in information, which are not commensurate with the scale of projects' analysis, project proposals are not yet considered finalized at this stage.
- Smooth Polygons – using Bezier operator that builds curves based on the original vertices, but simplifies them.
- Generalization/Elimination – Deleting polygons that are very small. It is important to specify dimensions of the polygons to be eliminated, according to

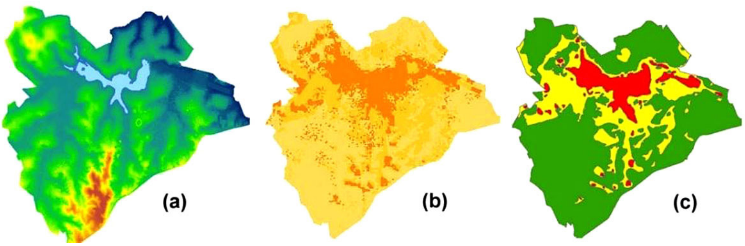

Fig. 5. Example of representation, process and evaluation models of "Visual Axis" in Pampulha. The representation model (a) illustrates the topographical conditions in Pampulha obtained by digital terrain models and digital surface model (LiDAR -– Light Detection and Ranging); the process model (b) illustrates the calculation of the target field from the visitation areas of cultural heritage in Pampulha; and the valuation model (c) indicates where it is necessary to preserve the landscape and stop increasing verticalization (red) and where the impact of transformation in targeted fields is less harmful (green)
Source: Produced by authors using ArcGIS.

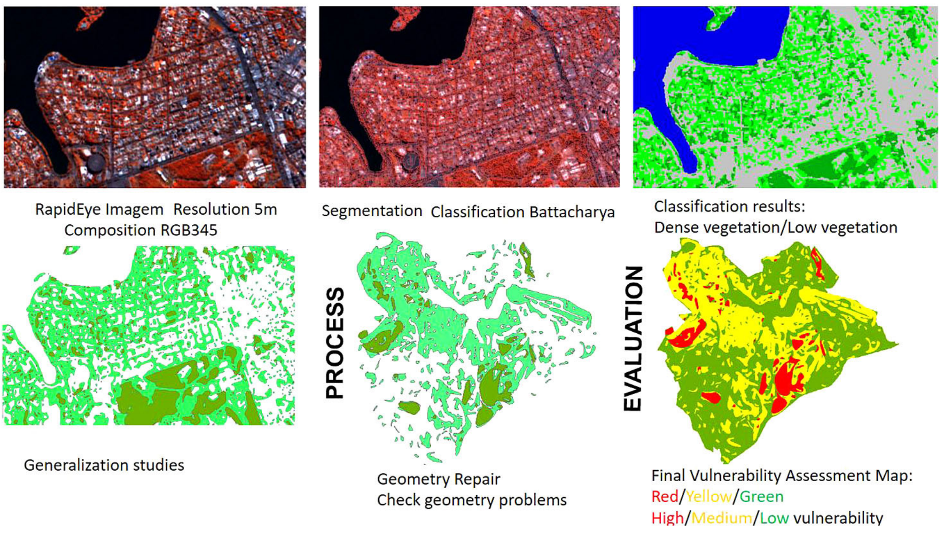

Fig. 6. From representation to process and evaluation Models: the model generalization
Source: created by the authors using ArcGIS and RapidEye image.

the precision levels needed for the analysis. For example, one can determine that polygons smaller than the width of urban road will be deleted. The system identifies these small polygons and changes their attributes to receive the same characteristics of the neighbors, which makes it possible to dissolve the smaller ones into the larger ones.

- Validate Topology – To avoid geometric conflicts overlapping polygons.

After this process, the calibration is performed by consulting users in order to obtain a visual representation, which reflects their expectations regarding maps.

The first iteration

The first iteration, conducted in Horizonte in August 2015, was focused primarily on the conceptual design of alternative futures for the region of Pampulha, in order to guide the growth and use of urban land and at the same time protect environmental resources, natural, and cultural areas (Campagna et al. 2016, p. 293). The group from Geoproea developed 10 systems concerning the Representation, Process and Evaluation Models. The systems represent the variables: Visual Axis; Historical, Cultural and Natural Values; Surface Water; Vegetation; Building Volumetric Density; Public Transport; Commerce, Industry and Services; Housing and Urban Dynamism. They were divided into "vulnerability" and "attractiveness" (Fig. 7).

For the first iteration Geodesign Hub was chosen as a tool for practical testing. Geodesign Hub is a software for Web 2.0, developed based on the Geodesign methodology (Steinitz 2012, Ballal 2015). It allows the creation and sharing of concepts in projects collaboratively developed in decision-making processes. Its

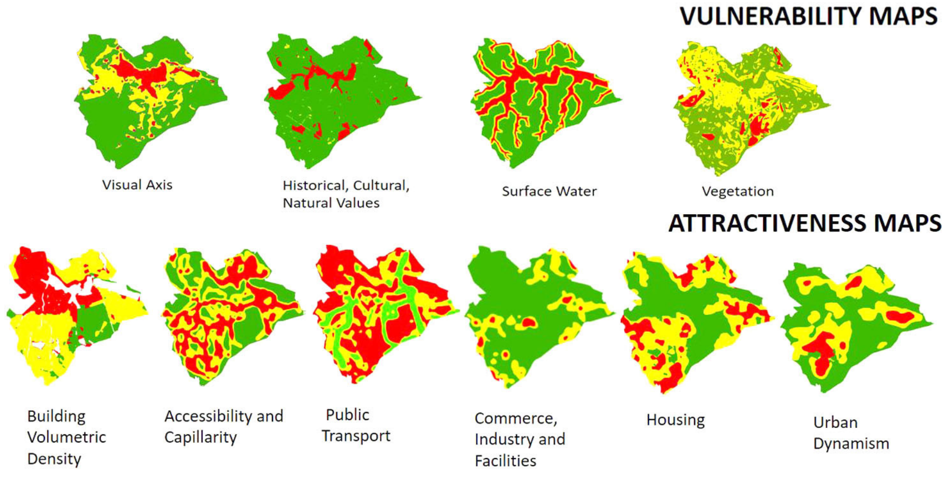

Fig. 7. Vulnerability: Visual Axis; Historical, cultural and Natural Values; Surface Water; Vegetation. Attractiveness: Building Volumetric Density; Accessibility and Capillarity; Public Transport; Commerce, Industry and Facilities; Housing, Urban Dynamism. In green go for it; in red to be protected, already developed or not priority
Source: created by the authors using ArcGIS.

organization is open to receiving change and its assessment can be made almost in real time. According to Campagna et al. (2016), Geodesign Hub has broader potential than other PSS tools as it is strongly linked to geography and design in collaborative and participatory processes.

Twenty-one participants were selected by the organizers to join the workshop. The participants were divided into six interest groups: Conservation Heritage Cultural, Chamber of Commerce, Developers, Green NGO ("friends of earth"), Public Administration and Local Residents. The groups specified a hierarchy of importance between the systems considering their research goals, and carried out the proposition diagrams for each system, followed by rounds of choosing the best diagrams, which should make up the proposal for alternative futures for Pampulha (Fig. 8). The diagrams were separated into project and policy proposals. Dynamic assemblies were performed by rearranging the six groups into three

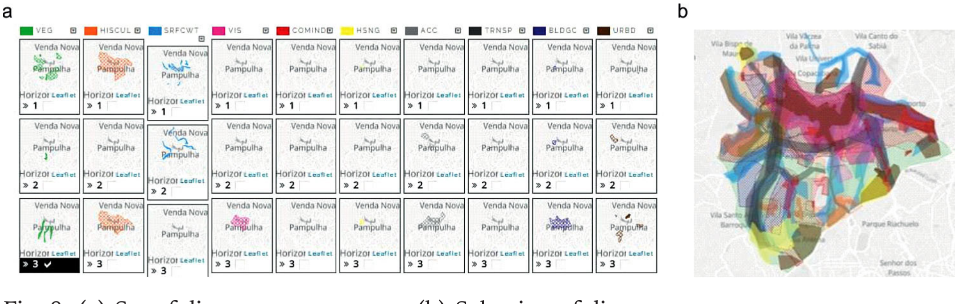

Fig. 8. (a) Set of diagrams per system, (b) Selection of diagrams
Source: created by the authors using Geodesign Hub.

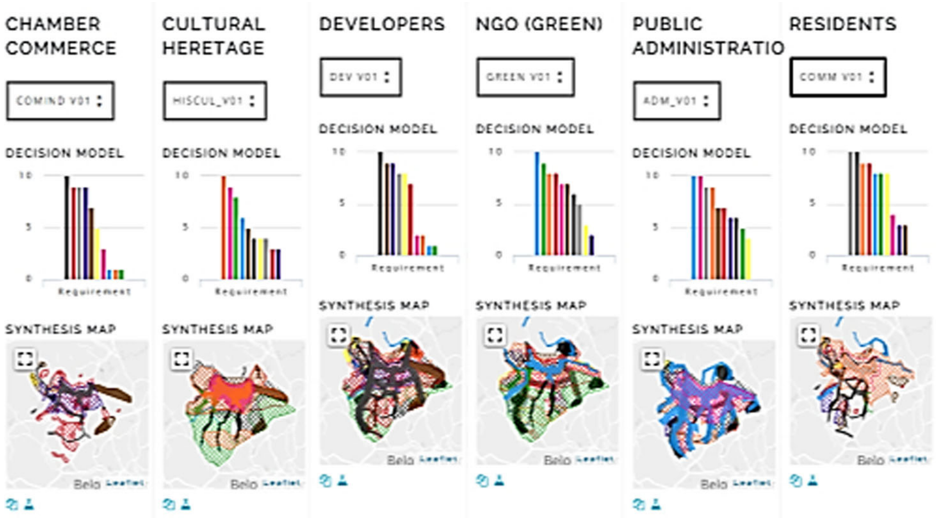

Fig. 9. Proposals made by the groups (Synthesis Map), preparing to compose draft collective agreement. The groups were Chamber Commerce, Cultural Heritage, Developers, NGO (Green), Public Administration, Residents

Source: created by the authors using Geodesign Hub.

and then into a single one, aiming to build a single proposal as a representation of collective agreement (Fig. 9).

As each set of diagrams was chosen by the system, the impact of the proposition was evaluated so the system was fed with "cross tables" that defined what it meant to suggest a diagram type in certain territorial conditions (Fig. 10). The areas on the proposed diagrams were also calculated, in order to check the cost of the proposal (cost per hectare must be provided in Geodesign Hub) and the range of the target (the amount of area to be allocated for each system must also be given in Geodesign Hub).

The first iteration reached three possible scenarios for Pampulha. During the first iteration comments about process improvements were received from participants, followed by interviews aimed at eliciting more comment-specific details. The goal of the second iteration was to answer the question of "how" should the process be done.

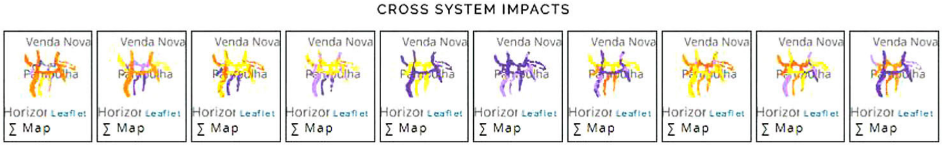

Fig. 10. Proposals from the impacts of evaluation on different systems. All the maps represent Cross System Impacts

Source: created by the authors using Geodesign Hub.

The second iteration

The second iteration comprised the review of the workshop experience through interviews with participants and, above all, through the evaluation of experienced planners on issues of cultural heritage, urban planning and landscape management.

The second iteration was necessary to review the results of first iteration and prepare the third one. Its main objectives were: (i) review the variables and systems used in the first iteration; (ii) preparation of the bases for the third iteration, including data review through research on mechanisms and ways to expand the visualization and explore this resource in decision-making.

These interviews with the people who took part in the first iteration were conducted by an online tool from Google (Zyngier 2015a), supported by a shared explanation video on YouTube (Zyngier 2015b). The interview results were sent to experts on Pampulha. The video began by recalling key aspects of the first iteration and asked participants to collaborate in the review stage, through the analysis of the chosen variables.

The online form presented the variables used in the first iteration and participants could select from the choices: “keep”, “delete” or “add new variable”. The selection choices had to be justified. The results were very productive and it was possible, surprisingly, to observe that the responses suggested that most of the variables and issues indicated have already been displayed in the first iteration (Fig. 11). The main need for new variables included social aspects such as income, distribution of sewerage and sanitation facilities, as well as schools and health centers. Some questions emerged: Why did the participants did not see the need for some of these variables in the first iteration? What were the problems in visualization?

During the second iteration, suggestions were received regarding the process models and their systems. The main suggestions were: (i) inclusion of spatial references in order to make easier the understanding of the distribution of variables; (ii) review of subtitles by choosing representative classes according to the perception of the area.

The third iteration

The third iteration took place in early 2016, and aimed at getting the opinion of people divided into groups representing the most appropriate places to authorize the increase of occupation density in Pampulha. It was conducted by Geoproea group.

Fourteen systems were created (instead of ten in the previous two iterations) to represent the suggestions of participants during the second iteration. The systems aimed to clarify socio-economic distribution conditions (especially income factors), infrastructure conditions (sewage), and public services (schools and health centers) and to broaden the analysis of the potential areas for new occupations through showing the predominantly empty areas (Fig. 11).

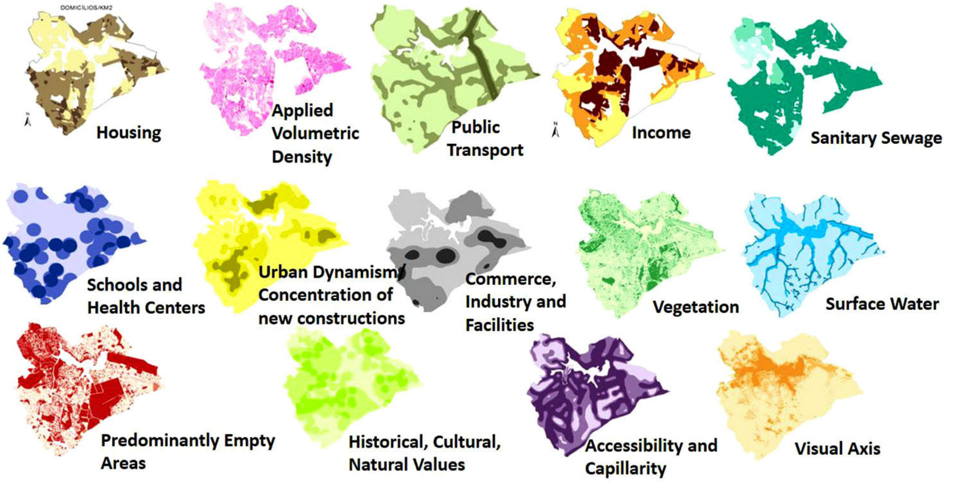

Fig. 11. Fourteen systems used on the third iteration
Source: created by the authors using ArcGIS.

In addition to the variables and systems review, a new graphic treatment was adopted. A range of colors was applied in order to replace the semaphoric colors (red, yellow, green) used in the first iteration. The lighter tone meant lower con-

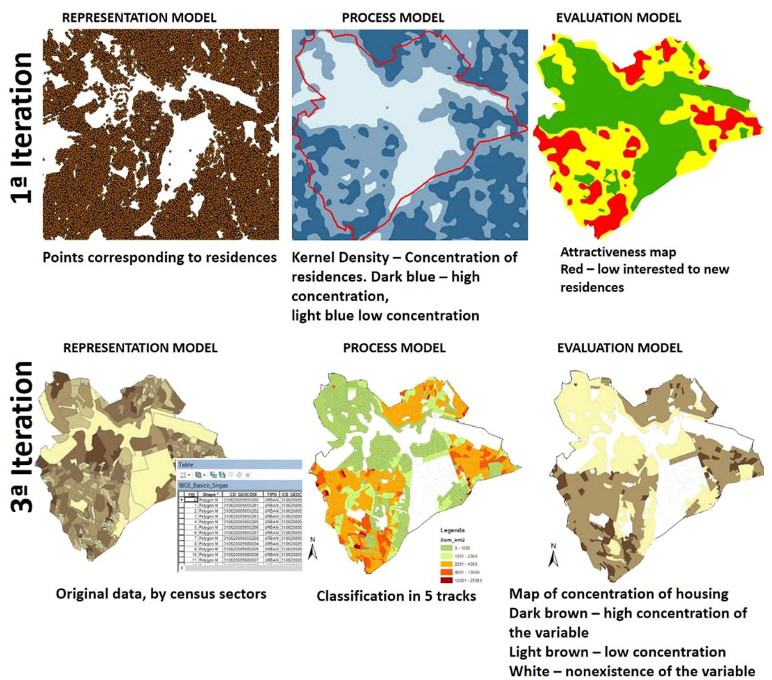

Fig. 12. Change in the graphic treatment of information
Source: created by the authors using ArcGIS.

centration of the phenomenon or variable, as the darker tone meant higher concentration of the same phenomenon (Fig. 12).

Third iteration development

The experience in Geodesign studies at Pampulha made it clear that the collection of data and information to support opinion making should be divided into base maps (to facilitate users' query for specific information, i.e. maps of location references) and maps of processes of variables (Fig. 13) and into systems that make up the bases for building diagrams. The third iteration presented to users these two map collections. The support maps were presented in analog (print) and digital mode and the systems were presented in digital mode.

Participants were divided into six working groups: local residents, government, environmental, historical and cultural, chamber of commerce, and entrepreneurs. Assistants were in charge of driving the software (ArcGIS) and assisting with layers' selection activities (i.e. overlays, digital drawing diagrams suggested by the group or designed for them on paper).

After receiving maps, groups were asked to propose diagrams to answer the key question: where to densify in Pampulha? During the first day, it was observed that all participants preferred to use printed maps to develop early studies of diagrams. The digital map collection was not consulted at this stage. It was up to the assistants to export diagrams from paper to digital format.

Once the diagrams were designed in ArcGIS, the assistants run histograms for each diagram. This step allowed the participants to check if each diagram location was in an area with high, medium or low conditions concerning the phenomena distribution in each system. Histograms were computed for each of the fourteen systems, keeping the colors of system maps, which helped the identification of the best diagrams and the review of proposals (Fig. 14).

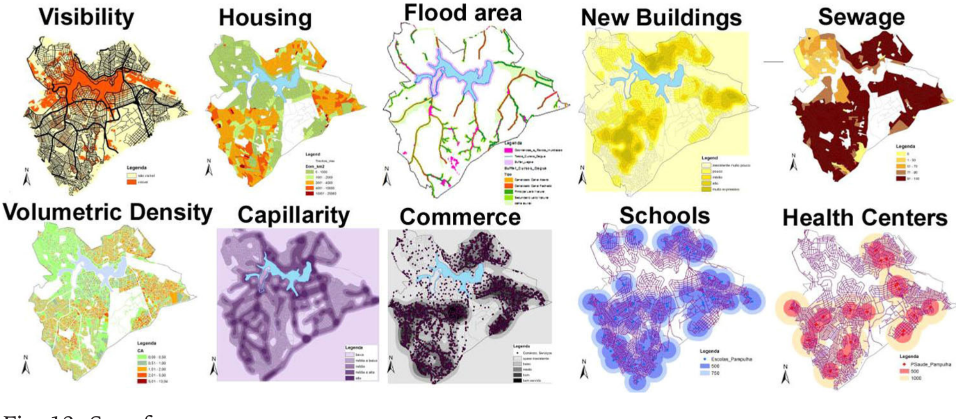

Fig. 13. Set of some process maps
Source: created by the authors using ArcGIS.

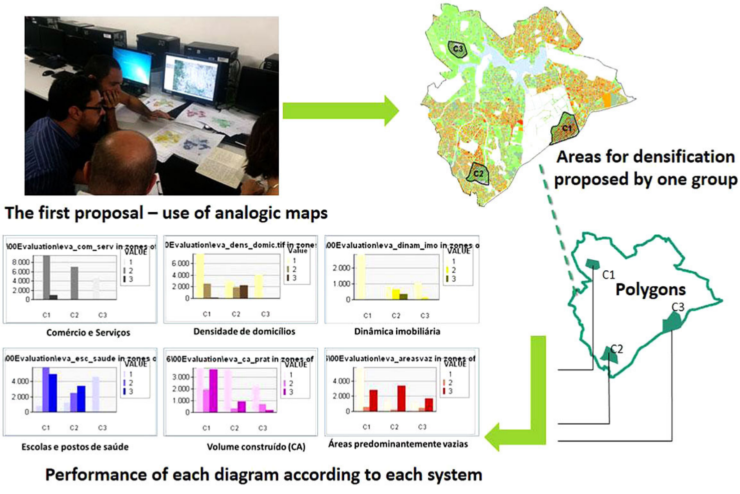

Fig. 14. Performance study of each diagram using histograms
Source: adapted from Zyngier C. 2016a.

Considering the performances of the first sets of diagrams, evaluated according to histograms performances, each group had the opportunity to review their own diagrams and draw up a new proposal represented in the second set of diagrams. After that, the first six groups were reorganized into three new groups, according to their preference affinity. The affinity was identified in each group by voting to reveal whether they were in agreement or not with the proposals of the other groups. The next step was the production of new sets of proposals translated into diagrams, by choosing existing diagrams or by editing or composing new diagrams. Again the performance of the diagrams was evaluated by histograms.

The three groups were tasked with developing a single final proposal. The selection mechanism used was voting diagrams. The support team removed names and authorships from each diagram, in order to facilitate choices without bias. Thus, the vote should take into account only the suitability of the diagram position and its performance. A list of all diagrams was organized in a table, and groups were asked to analyze each diagram and their histograms and vote be-

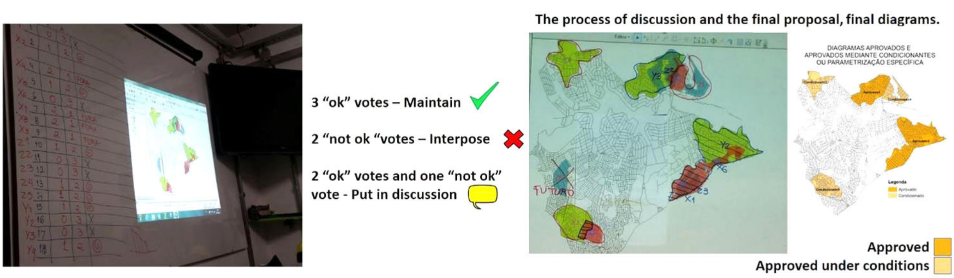

Fig. 15. Voting table evaluation and final diagrams
Source: adapted from Zyngier C. 2016a.

tween: (a) maintaining the diagram; or (b) dismissing the diagram; or (c) placing the diagram under discussion for all participants.

The vote followed the answers: “ok” or “not ok”, collected in table for each diagram. Three votes “ok” meant “maintain”, 2 votes “not ok” meant “interpose”, and 2 votes “ok” plus 1 vote “not ok” put the proposal “in discussion”. During the discussion, the group that voted against a diagram had to explain the vote. Similarly, group(s) that favored a diagram had to explain its rational. Some diagrams were accepted under certain conditions, while others were interposed (Fig. 15).

Conclusions

Geodesign is, above all, an opinion support system. Participants are placed collaborating in a dynamic environment that encourages them to present their opinions, listen and visualize other people's opinions, and then collectively build an alternative future management proposal for a landscape. Even when Geodesign is not applied specifically to support decisions, it supports opinion sharing and documenting in visual format, which is already an important contribution to planning process.

The tests of different visualization modes demonstrated the importance of having flexibility to adopt language and media that best match the users’ profile and case studies. In the first iteration there was a negative reaction against the semaphoric color scale because some people did not like the idea of using a classification scheme imposing rigid rule (3 classes) for where they should or should not propose their diagrams.

As a result of analysis and revisions made in the second iteration, systems were delivered to participants considering how a given variable was present or not in the territory, and then it was up to each participant to decide where they preferred to put their diagrams. This procedure was the criticized by the participants for stifling their design choices. On the other hand, the comparison between systems was difficult because each had a representation in a system-specific color scale.

The use of histograms for evaluation of diagrams performances was considered positive. The advantage of the third iteration experience in relation to the first is that in the first iteration the histogram corresponded to the performance of all system diagrams, while the third iteration histograms captured the performance of each individual diagram. This favored the choice or adaptation of each diagram more accurately. In this sense, this caution is critical for studies of more specific decisions, as was the theme question that guided the third iteration: where to densify?

Regarding the results, the first iteration process presented a general alternative future scenario. The third iteration, that had a more specific set of key questions, achieved more detailed and accurate results. The discussions, in general, led to reflections and developments related to the landscape concept, interference at architectural scale in the urban space and vice versa.

The involvement of different stakeholders was interesting both for bringing diverse opinions, as a challenge to building consensus, but also to allow the methodology transfer. The general results considering the diverse compositions of participating actors with different backgrounds showed that the proper selection of methods and tools can indeed contribute to building consensus.

An important learning process of Geodesign is its potential as an educational process in collective decision making. People are put in a situation in which they reflect on values and expectations, express and record their opinions, but above all learn to better listen and be open to proposals from other people and groups. The most interesting part of the process is undeniably its capacity to see people choosing project proposals and policies on the bases of their performance, reducing the impact of prejudices and biases.

A paradigm shift happens when participants go from the inflexible defense of an idea to reflection considering other groups "thoughts" and different proposals. It is remarkable how this change in group dynamics significantly contributes to reaching a final solution that is accepted by the majority. In this sense, the main product of Geodesign is the process of learning to share opinions and to test a way of participation that reduces the value of lobbying eloquence and promotes the value of the quality of the proposal.

Another important lesson, given specially the Brazilian culture, is to expand the analysis axis to the proposition axis. The Brazilian, in general, is quite satisfied to reach the analytical stage, but does not follow through into the proposal stage. By stepping trough, the "representation", "process", "evaluation" models, but only as a requirement to get to "change", "impact" and "decisions" models, the Geodesign dynamics requires the participants to make choices and to evaluate them according to their performances.

Acknowledgements

The Project "Geodesign and Parametric Modeling of Territorial Occupation: new resources of geo-technologies to landscape management of Pampulha Region, Belo Horizonte", was made possible in part by the support of National Council for the Scientific and Technological Development, Call MCTI/CNPQ/MEC/CAPES N° 22/2014, Process: 471089/2014-1, and to the Project "Programa Pesquisador Mineiro – PPM IX", Process TEC – PPM – 00059-15.

We kindly thank Prof. Carl Steinitz and Hrishikesh Ballal for their support in Geodesign. We thank Prof. Michele Campagna for conducting the 1st workshop, the 1st iteration.

References

Ballal H. 2015. Collaborative planning with digital design synthesis. Doctoral dissertation, UCL (University College London).

Campagna M. 2013. Geodesign, sistemi di supporto al piano and metapianificazione. DisegnareCon, Università di Bologna, 6(11): 133–140.

Campagna M., Moura A. C., Borges J., Cocco C. 2016. Future Scenarios for the Pampulha Region: A Geodesign Workshop. Journal of Digital Landscape Architecture, Berlin/Offenbach, 1: 292–301.

Campagna M. 2016. Sistemas de Suporte ao Planejamento (Planning Support Systems): Retrospectivas e Prospectivas. In: A.C. Moura (org.). Tecnologias da geoinformação para representar e planejar o território urbano. Interciência, Rio de Janeiro, pp. 217–252.

Magalhães B. 2016. Geodesign: conceitos e arcabouço metodológico. In: A.C. Moura (ed.). Tecnologias da geoinformação para representar e planejar o território urbano. Interciência, Rio de Janeiro.

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

Zyngier C. 2016b. Paisagens urbanas possíveis: códigos compartilhados através dos Sistemas de Suporte ao Planejamento e do Geodesign. PhD Thesis, Federal University of Minas Gerais, Brazil.

Zyngier C. 2015a. Preparação para nova iteração. Available at: <https://docs.google.com/forms/d/1DL6xQA44fxrpOKzv-4Ivrptpsp3mi-rNwUfZuuDr5hw/viewform>.

Zyngier C. 2015b. Pampulha: futuro alternativo. Available at: <https://www.youtube.com/watch?v=cWnRNbDLrNA&index=3&list=LLAgpWh1pQ09GweiG-VoLNKw>.

Zyngier C. 2016a. Paisagens urbanas possíveis: códigos compartilhados na construção coletiva de cenários. In: A.C. Moura (ed.). Tecnologias da Geoinformação para Representar e Planejar o Território Urbano. Interciência, Rio de Janeiro, pp. 61–88.

Geodesign w miejskim obszarze dziedzictwa kulturowego Pampulha: narzędzia wizualizacji w planowaniu rozwoju miasta

Streszczenie: Celem opracowania jest omówienie roli wizualizacji w metodologii geodesignu, uwzględniając jej zastosowanie na przykładzie rejonu Pampulha w Belo Horizonte, Minas Gerais w Brazylii. Chcąc wziąć pod uwagę opinię uczestników, praca ich została zarejestrowana na różnych etapach procesu planistycznego, w różnych wersjach koncepcji geodesignu. Przetestowano też różne możliwości wizualizacji. Metodologia geodesignu została zastosowana w różny sposób i z użyciem odrębnych narzędzi. Celem było określenie czy różne techniki i narzędzia wykorzystane w procesie geodesignu przyczyniły się do coraz lepszego rozumienia gromadzenia danych i rozwiązywania problemów, jak i do czerpania korzyści z udoskonalonych technik i narzędzi geodesign.

Słowa kluczowe: planowanie partycypatywne, geodesign, wizualizacje, rozwój miasta, transformacja przestrzeni zurbanizowanej