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Interoperability and visualization as a support for mental maps to face differences in scale in Brazilian Geodesign processes

Abstract: The paper presents case studies of geodesign and collaborative planning in the context of important cultural areas in Minas Gerais state, Brazil, "Pampulha" and "Iron Quadrangle". The first area is at urban scale and has recently received UNESCO recognition due to Oscar Niemeyer's work, and the second is at regional scale and of qualified landscape, important historical and cultural values, in addition to abundant natural resources (mainly minerals). The results allow a reflection on the role of interoperability and visualization applications to favor mental maps and better conditions in participatory planning, based on the methodology of Geodesign.

Keywords: Geodesign, Interoperability, Mental Maps, Collaborative Planning, Visualization

Introduction

The recognition of the landscape value and the interest on preserving the essence of the place are quite recent in Brazil. Only since the City Statute (*Estatuto da Cidade*), law passed in 2001 (Brazil), and the approval of the Seal of the Brazilian Cultural Landscapes from 2009 (IPHAN) the landscape protection has started to be mentioned. However, there is still no instrument available to guide the identification, classification, characterization to occupy and preserve the landscape. This problem is amplified given that landscape management is a complex process with a number of interdependencies. The work described in this paper relates to including geographic information technologies in the process of identification, planning and management of the landscape in Brazil. The visualization and the decision-making processes regarding the landscape management are assessed by the use of Geodesign methods.

The Geodesign methodology was first proposed by Steinitz (2012), based on a landscape representation by several systems that can capture the essence of main values. What makes geodesign fundamentally different from traditional design or planning processes is its workflow, the process of creating a design. Steinitz developed a model of landscape change that enables design of alternative futures and over 25 years has used this in a number of studies (Steinitz et al. 1996, Steinitz 1990, Steinitz 2001). In 2015, the framework was transformed into its digital representation and a software that enables a digital design workflow, and it was tested in a number of workshops (Ballal 2015, Rivero et al. 2015, Nyerges et al. 2016). Geodesign is a multidisciplinary collaboration with direct interaction among design professionals, geographically-oriented scientists, information technologies and the people in a setting, in which computers provide rapid responses to changes in the design created by various participants. The ability to create a design collaboratively and rapidly, and to measure design impacts differentiates it from traditional design processes.

Geodesign Hub is built for early stage strategy formulation in diverse design problems. Usually the design problems are by their nature complex and there can be almost infinite designs to solve a problem. The Geodesign approach enables the participants to very quickly parse the multitude of potential design solutions and hone in on a set of designs where the solution lies.

Geodesign done digitally requires an organization of a georeferenced database, which enables the use of spatial assessment models. The systems constituting an area under design are organized into evaluation models and maps that demonstrate where there are specific needs for change, improvement, investments and specific care. Based on the information present in these maps, stakeholders develop diagrams encapsulating proposals for policies and projects that improve the system (Fig. 1). As an example, participants in a Geodesign process can propose diagrams to create new conservation units as a reference system that informs about the presence of robust vegetation and the distribution of water network.

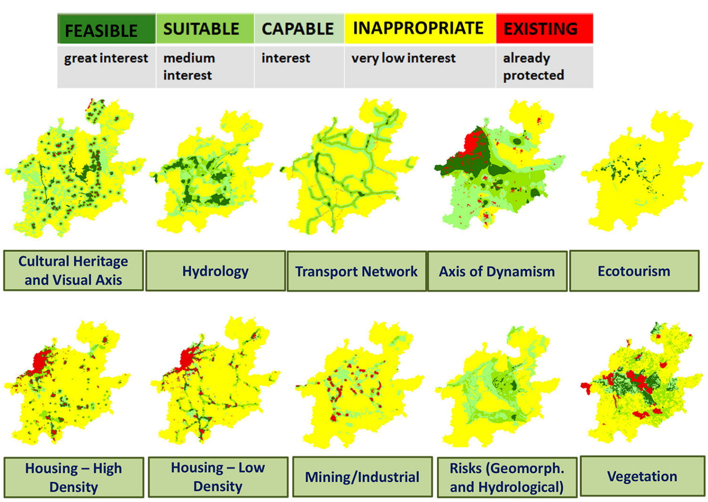

Fig. 1. Example of Geodesign systems modeled for Iron Quadrangle region.
Source: The authors; developed in Geodesign Workshop "Quadrilátero Ferrífero".

A Geodesign workshop aims to bring together people deciding about alternative futures for a landscape or a land use. The participants are organized in teams that represent political, professional, economic and/or social interest, and work towards the synthesis of design by selecting projects and policies from different systems that best suit their or their client interests. To support their decisions, the diagrams are analyzed for impacts in real time. In addition, the synthesized designs are compared among the groups, according to their preferences and knowledge about the area of study, and verified that they are not in conflict with other potential uses or expectations (Fig. 2). By the end of the process, the groups agree on a negotiated set of diagrams that arises from the number of iterations of collaborative design making.

The hypothesis that guides this research assumes that users have different preferences for viewing geographic information, as they can use, for example, Geographic Information Systems, social media applications, web maps, among others. Starting from this assumption, we argue about the importance of interoperability for the geo-information technologies that favors easy navigation between applications and takes advantage of social media geographic information platforms. We believe that the ability to go from one application to another in order to visualize results can improve the capacity for participation and understanding in decision and opinion support systems, such as Geodesign workshops based on Geodesignhub.

To illustrate the above hypothesis, corroborated by a larger number of experiences in participatory planning in Brazil with the use of geo-information technology resources, two case studies were chosen. The selection of the two studies serves only to illustrate the role of visualization improvement, supported by the full use of interoperability that allows the use of different platforms.

The case studies illustrated in this paper describe the process of Geodesign and collaborative planning in the context of important cultural areas in the State

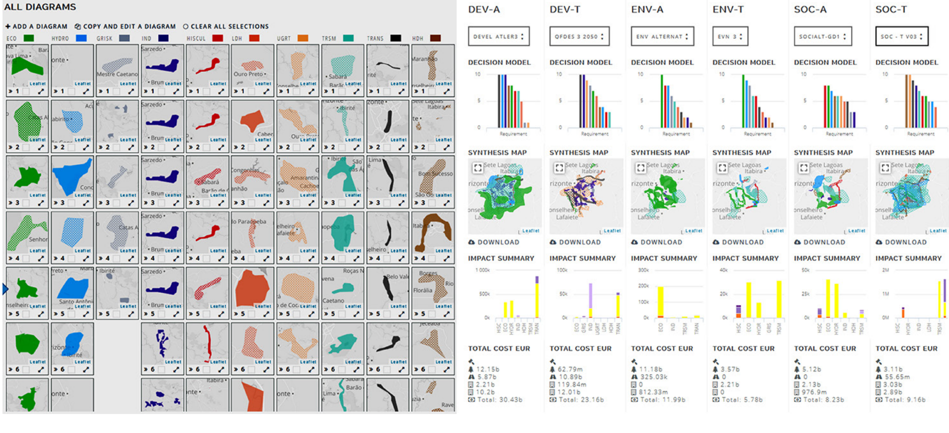

Fig. 2. Example of Iron Quadrangle Geodesign workshop: diagrams proposed to each system, examples of plans proposed by each group and the performance of the proposals
Source: The authors; developed in Geodesign Workshop "Quadrilátero Ferrífero".

of Minas Gerais, Brazil. The two study areas described in this paper present qualified landscape, important historical and cultural values, in addition to abundant natural resources (mainly minerals). The results allow a reflection on the proper uses of the remarkable and important landscapes in Minas Gerais: "Pampulha" and "Iron Quadrangle".

The first study, conducted at an urban scale, presents the Pampulha area, the modernist urban and architectural design, considering not only Oscar Niemeyer's work itself, but also the context of its insertion into the landscape. At a regional scale, composed of natural and anthropized environment, the second study presents the "Iron Quadrangle", the main area of cultural heritage in the state, not only due to its historical heritage, and art collections, but also because of notorious landscapes, natural resources and the transformed landscape as the result of intense mining exploitation activities. Both areas face conflicts of interest between different stakeholders with regard to their management. Specifically, they have a variety of options for the anthropic use of landscapes, and the possibility of assuring the dynamic balance between environmental sustainability and economic exploration of land, such as mining.

The Pampulha region in Belo Horizonte (Minas Gerais, Brazil) was selected for the urban scale case study. As a collection of architectural values at an urban scale, at the time of the workshop, Pampulha was a candidate for the World Heritage title by UNESCO, which it received in July of 2016. Oscar Niemeyer's works basically compose the Pampulha, turning it into one of the few places in the world where the modern idealism was very well planned and illustrated, and resulting in a heritage site of unquestionable value. However, the revision of the Master Plan is required considering that there is no sense in protecting only the specific area of Niemeyer's work avoiding its surroundings. It is important to include in the revision the insertion context of the landscape managing the existing conflicts of interest (Fig. 3).

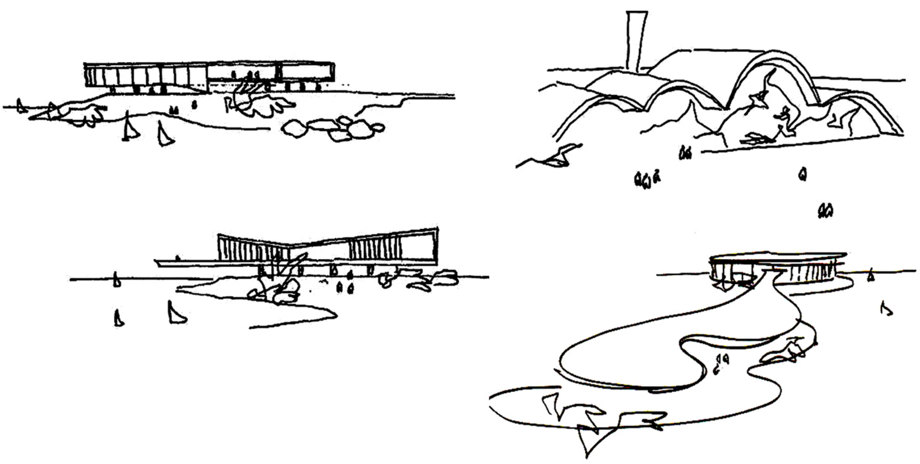

Fig. 3. Pampulha Modern Landscape – Oscar Niemeyer drawings
Source: Pinterest from Arcoweb.

Fig. 4. Remarkable cultural landscape of the Iron Quadrangle. Economy and Heritage
Source: Pinterest and personal pictures made by the authors.

At the regional scale, presenting environmental and anthropized landscapes, the case study is about the "Iron Quadrangle" region. This area presents a remarkable landscape, which translates the *genius loci* of Minas Gerais state. The first cities in Brazil that nowadays are the main Brazilian historical heritage sites were settled in this region. Explorers were attracted to Minas Gerais by the mountain chains of the Iron Quadrangle, where mineral resources were plentiful. However, there is a dynamic transformation concerning the environmental values and the remarkable landscape of the cities' networks due to the mining activities and the expansion of urban areas (Fig. 4).

Conceptual basis – geodesign, visualization and interoperability

In Geodesign methodology, Steinitz (2012) presents a framework for organizing and conducting a planning, design and decision making study. The "Steinitz Framework" provides a methodology to organize data and systems for a study area. The setup process of organization allows the organizing team to identify and gather the key factors and systems at play in the study area and their dynamics. Once the problem is known, groups representing different interests (i.e. economics, tourism, industry, health, etc.) are requested to create proposals in the form of policies and projects. The impacts of these proposals are calculated considering the costs (cost of implementation, per area) while taking into account the limits of acceptable carrying capacity (targets) for the land transformation in real time.

Geodesign Hub enables a transparent and collaborative design environment where each group presents their proposals and can analyze the other groups' proposals. The tool enforces a common language of color that enables quick communication. The workflow provides a number of opportunities to hone in on their visions through dialogue with the different actors of the society, and to understand their logic and values. Best used in the early conceptual stages of the problem, the workflow enables different teams to rapidly iterate through their designs to generate a concept that can be quickly understood by all participants. As the participants progress in the process, the ability to generate a consensus is provided. The process structure balances the drive toward the maximization of group agreement with the reality that there is no such thing as absolute consensus, but instead, it is possible to manage a collective decision. The process is flexible to adjust the models according to the territorial and cultural realities; thus, it is reasonable to design the landscape in a contextual approach regarding specific local needs.

The main characteristic of Geodesign methodology is the necessity of iterations, collective revisions and shared decisions (Goodchild 2010, Campagna 2013). It is important that the involved actors understand the process and the justification for the use of information visualization to support their decisions. The goal of using the visualization support is to make people understand and take part in landscape planning according to their cultural values and by considering a common sense. (MacEachren et al. 2004, Kingston 2007, Abukhater, Walker 2010, Andrienko et al. 2011, Pensa et al. 2013, Manovich 2014, Ferreti et al. 2014, Ferreti et al. 2015). The logic is clearly exposed by Miller (2012): "*The best way to predict the future is to propose it*".

The two case studies – Pampulha (urban scale, neighborhood scale) and Iron Quadrangle (regional scale, a territorial landscape analysis) – demonstrate the real world examples where the process was used as a decision system for landscape planning. The studies were conducted as an opinion support system, in which different groups from society were put together to think about alternative futures for the common landscape. From these experiences, we observed the importance of visualization to make people understand "where, how and how much", while they were proposing the projects and policies to the areas.

During the experiments and following our observations, we let the users to elect their own tools for diagrams' creation and visualization. Both case studies involved participants from different professional backgrounds and personal experiences. Given this, we recognized the need for the users to have the ability to use the tools that they were most familiar with. Thus, they could have more confidence to analyze the study regions, and to propose policies or project diagrams for the study areas. This condition can be achieved by interoperability among data and systems.

According to Bishr (1998), "interoperability" is the ability of a system (computerized or not) to communicate transparently (or as close to it as possible) with another system (similar or not). For two systems to be interoperable, they must be able to exchange data and subsequently present that data such that it can be understood by a user (or a machine). Considering a computational environment, these systems must interchange data by sharing a common protocol.

Geographic Information Systems (GIS) have been widely adopted over the past two decades in support of urban planning, forestry, agriculture, infrastructure maintenance, and many other fields. Each software product developed essentially independently, with little in the way of overarching theory or common terminology. As a result, it is very difficult for different systems to share data, for users trained on one system to make use of another, or for users to share procedures developed on different systems. Conversely, working with common files formats and interoperable data protocols can prevent incompatibility. Also, considering the end user, this practice helps to integrate with other databases avoiding rework and waste of time learning how to understand and read new data source.

In the geospatial field, data interoperability has been the target of major efforts by standardization bodies (e.g. OGC[1], ISO/TC 211) and the research community since the beginning of the 1990s. It has been seen as a solution for sharing and integrating geospatial data, more specifically to solve the syntactic, schematic, and semantic as well as the spatial and temporal heterogeneities between various representations of real-world phenomena. A few models have been proposed to automatically overcome heterogeneity of geospatial data and, as a result, increase the interoperability of geospatial data (Brodeur et al. 2003).

The term “interoperability” suggests an ideal world, in which these problems would disappear, or at least diminish significantly, as a result of fundamental changes in design, approach, and philosophy (Goodchild et al., 1999). If two systems are able to efficiently communicate, supporting each other data (reading and writing), they are considered to be interoperable. It is important that they work with popular and open formats such as shapefile (SHP), Keyhole Markup Language (KML), Web Feature Service (WFS), and others specified by the Open Geospatial Consortium (OGC) in order to integrate heterogeneous systems.

Methodology – interoperable approach for data visualization

Comparing the results produced in the two case studies, we observed the participants had difficulties in producing diagrams with a proportional scale and spatially representing a more precise location. In “Pampulha” case study, the participants were more assertive about the diagrams location, but they sketched bigger polygons than expected, even when knowing about targets (the dimensions of areas they were expected to project in each system) and costs (Fig. 5a). Especially, when working on large area regions, such as the Iron Quadrangle, they faced more challenges regarding the study area location and even more difficulty with understanding its dimensions, which resulted in proposing polygons that were even larger than big existing cities in the area (Fig. 5b and c).

This lack of perception in location and dimensions made us think about the difficulties of the participants in associating digital representation with their mental representations of the territory. It’s true that we observed just a few situations, and it would be important to verify whether this condition is just a local problem or not. However, we decided to invest in visualization to face this challenge. We also had to take into account that some participants did not have experience related to urban and landscape planning. Thus, they must face more barriers when working with virtual models as a representation of the reality.

In the case studies, the visualization could contribute not only to construct a bridge to link reality and modelling, but also to make people recognize and work with spatial values that compose the place’s *genius loci*, in the sense proposed by

[1] OGC – Open Geospatial Consortium - http://www.opengeospatial.org/

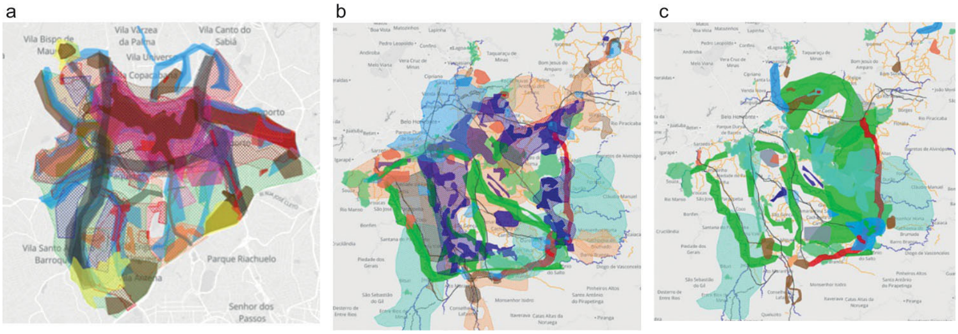

Fig. 5. Diagrams resulting from the Geodesign Workshop. (a) Pampulha case study. (b) Iron Quadrangle case study, developers' proposal. (c) Iron Quadrangle case study, ecologists' proposal
Source: The authors; developed in Geodesign Workshop "Quadrilátero Ferrífero".

Schultz (1980). This can be achieved simply by recognizing places and meanings that tell about the essence of an area, the interaction between space and identity. This is even more important in case studies concerning the remarkable cultural landscape management.

To promote better visualization some principles of mental maps must be reviewed. The approach is not new as it was discussed by a generation of authors. It is based on behavioral geography, and is found in the theories of perception (Lynch, 1960, 1972, 1976, 1981, among others) and the theories of cognition (Cullen 1961, among others). Lynch presented the idea that users construct mental maps from the territory using some common spatial elements as reference, which are represented by paths, edges, districts, nodes and landmarks. Cullen presents the idea of serial vision to explain how users organize mentally the relation between places to compose a mental map of an area. The new digital

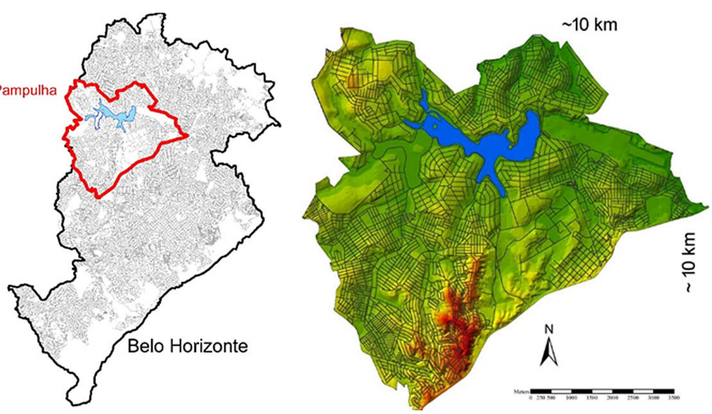

Fig. 6. Location and dimensions of Pampulha region (Belo Horizonte)
Source: The authors; complied for Geodesign Workshop "Pampulha".

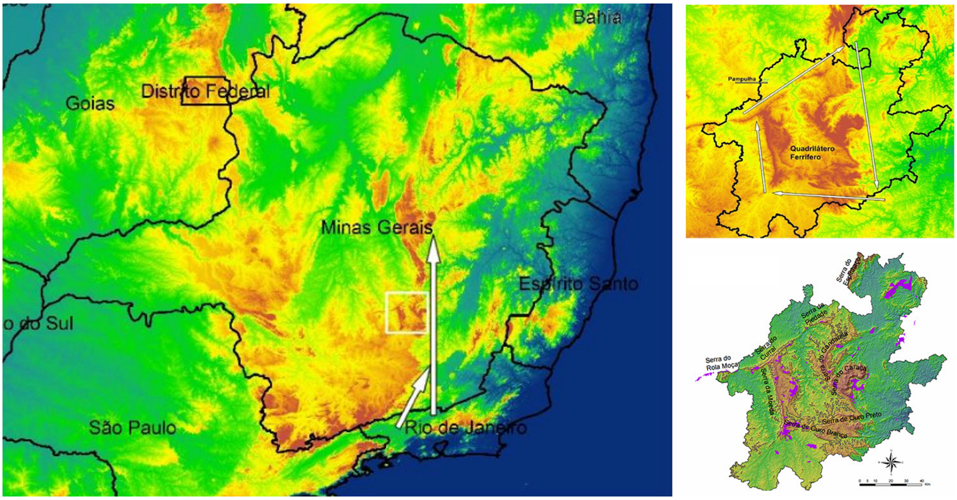

Fig. 7. Iron Quadrangle (Minas Gerais, Brazil) location and dimensions
Source: The authors; compiled for Geodesign Workshop "Quadrilátero Ferrífero".

tools can promote revisiting of these concepts in response to the need of using reference elements that favor the understanding of where, how, and how much.

At the beginning, we thought the problems in understanding the area was due to scale: Pampulha is an urban region of 51 km^2 within the city of Belo Horizonte (Fig. 6), and Iron Quadrangle (QF) is a territorial region of 11676 km^2 (Fig. 7). Because of the dimensions, it's possible that people know more about Pampulha than QF. However, it is true that people know some parts of each case study, and not the whole area in both cases. When we analyzed the resulting diagrams from the Geodesign Workshop experiences, in both cases they were oversized, but when we analyzed the locations, there was a difference between them: in Pampulha they were more precise.

The challenges faced by case study participants in connecting reality to digital representation and proposing diagrams in more precise locations can be explained by mental map references. In Pampulha, there are very clear spatial references: the lake, the airport, the zoo, the soccer stadium and the campus of the Federal University. Even if we use 2D representation, these elements compose referential locations and proportions. In QF the main references are the roads, the rivers and the plots of the cities, but they are not enough to produce a mental map because of the importance of topography. The main characteristic of QF is its chain of mountains. However, even when applying visualization techniques to represent topography in 2D, the 3D information is essential to be used as the basis for drawing the diagrams.

Understanding that 3D visualization was very important to create a mental map of QF, we decided to develop conditions to link the process in Geodesign hub with visualization tools as a contribution from our group. We also identified the importance of promoting interoperability among various systems, such that users could use their own methodologies and skills to obtain a better visualiza-

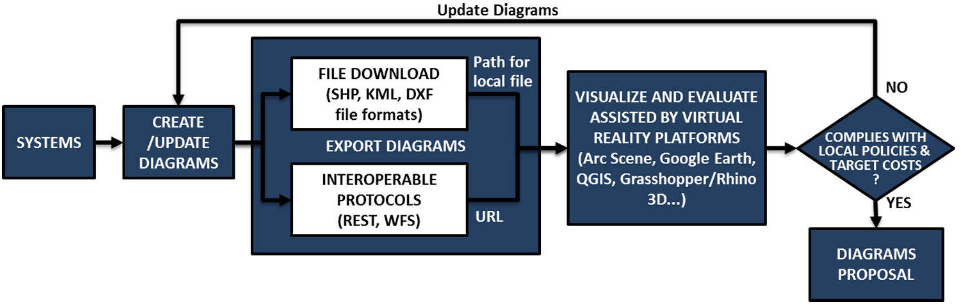

Fig. 8. Integrated data visualization and evaluation workflow
Source: the authors.

tion and promote a better evaluation, according to the characteristics of spatial elements that are keys to constructing mental maps.

The use of interoperability conditions in the system promotes not only a better visualization for the understanding of the study area and the construction of diagrams, but also gives conditions to allow each user to choose the tool he is more familiar with. The user can visualize the diagram in the applications s/he prefers (Google Earth, Google Maps, WFS Service to be used in Quantum GIS, ESRI ArcGIS, Rhino, etc.). Moreover, the user can draw or edit his diagrams and have them automatically uploaded into the system. In this sense, the user can feel more comfortable and confident in the process because he uses a shared code that is part of his own vocabulary. The methodology can be explained by the schematic diagram in Figure 8.

Development – data integration and interoperability

The Geodesign Hub allows each user to get an API token. Through this token, the user can achieve the list of diagrams from the projects he is working in the Hub using the "Tools to Geodesign Hub" presented at "ViconSaga" page[2] (Fig. 9).

In these tools the interoperability is promoted. Users can integrate specialized tools (freely elected by users according to their needs and skills) to create/update, visualize and evaluate environmental planning models. These tools can be simply and directly connected through common file formats and/or data protocols: shapefile (SHP), Keyhole Markup Language (KML), Web Feature Service (WFS), CSV to be used in Grasshopper or other applications.

If the user chooses Live KML for Google Earth, the diagrams are presented according to the 10 systems used in Geodesign Hub, which gives the possibility of organizing the layers according to the order of preference, and changing the colors (Fig. 10).

2 http://viconsaga.com.br/site/tool-geodesign-hub

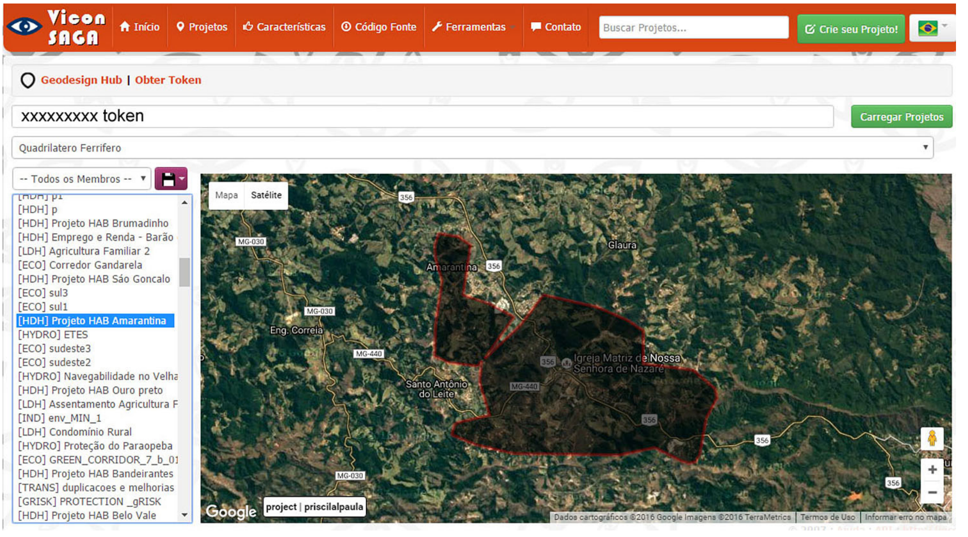

Fig. 9. Using the token from Geodesign Hub, the user can get all the diagrams from a project he took part in
Source: The authors, from ViconSaga website.

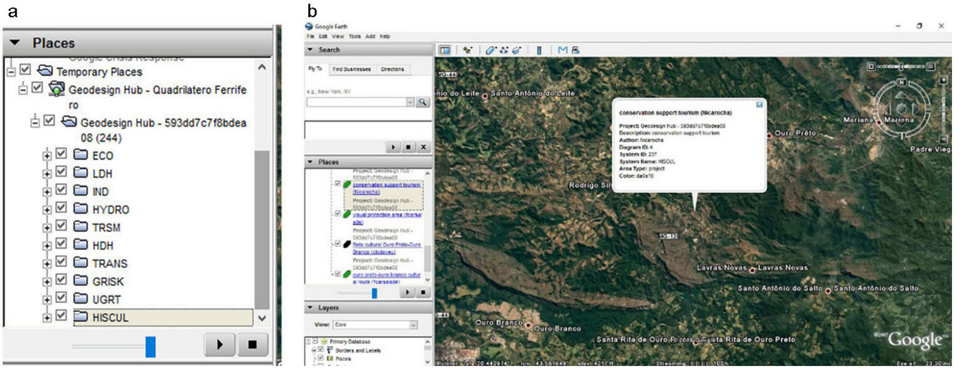

Fig. 10. Result of Live KML in Google Earth. (a) Diagrams organized according to the systems. (b) Visualization of all the information about each diagram
Source: The authors, using the application developed in the study.

Figure 11 presents examples of interoperability among distinct platforms. In the first example (a), models designed on Geodesign Hub platform can be directly analyzed and processed into Quantum GIS through WFS protocol. In example (b), Google Earth application connects to Geodesign Hub through REST (Representational State Transfer) protocol (Fielding, 2000).

User's visualization experience is enhanced by providing a three-dimensional view of diagrams that are overlaid on high-resolution satellite images. Similarly, as data originated in platform A can be connected, assessed, and modified in platform B, these new results can also be visualized in platform A. Therefore, interoperability allows data traffic in both directions.

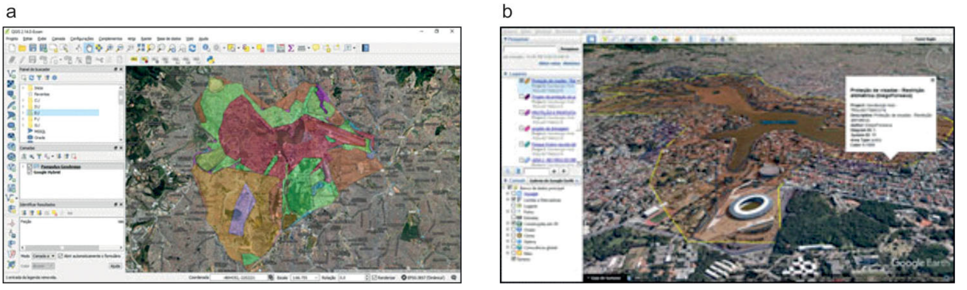

Fig. 11. Diagram models designed on Geodesign Hub platform directly overlayed and viewed in other platforms. (a) Quantum GIS connects to Geodesign Hub through WFS protocol; (b) Google Earth connects to Geodesign Hub through REST API protocol
Source: The authors, using the application developed in the study.

Conclusions and future work

The main goal of Geodesign is to lend support to opinion making. Geodesign – as a methodology to propose alternative futures for landscapes under varrying conditions and at different scales, faces challenges related to people working together sharing a common procedure. The methodology has an interdisciplinary nature and can be used by everyone, which means that the need for visualization support can be different according to the user. That said, for most of the users, a common code is a mental map of reality leading to a mental map of strategies.

Visualization tools can improve the capacity of understanding the where, why, how and how much in relation to policy proposals and projects. Interoperability is a bridge to put different tools working together as each application can support Geodesign work. Geodesign Hub has the goal to serve as a base for Change Models (the diagrams that represent where does change occur), Impact Models (the cross systems to calculate the impacts among the systems based on the diagrams proposed), and the Decision Model (the final project, composed of diagrams of policies and projects in each system, resulting from group decision). Interoperability tools allow the use of external applications to improve visualization conditions and the use of additional editing tools from Geographic Information Systems. The composition of a methodological scheme orchestrates the work giving support for the opinion making process that leads to the decision making stage.

In order to analyze the impact of visualization in the Geodesign process, a poll was conducted among the users that participated in two Geodesign case studies described herein. We asked them about the improvement in creating a mental map of reality using the visualization support promoted by interoperability tools, and if it made them feel more comfortable to create diagrams. The answer was very positive: 92% responded: "I think visualization tool enabled by interoperability extends the viewing capabilities of the topography and the existing situation, favoring best diagrams". The other 8% answered: "I think it makes no difference in the preparation or choice of diagrams".

The other issue, not discussed in the paper, concerns graphics semiology applied to visualization in order to choose the best representation according to the objective of communication (Moura et. al. 2016), and the selection of spatial analysis tools to be used by non-technical participants. The issue of graphic semiology, spatial analysis functions for non-technical participants, as well as the interoperability of visualization tools aim at a larger goal of improving and facilitating Geodesign process under different conditions, scales, cultural and local needs.

Acknowledgements

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Interoperacyjność i wizualizacja jako wsparcie dla map mentalnych w różnych skalach przestrzennych. Przykłady zastosowań Geodesignu z Brazylii

Streszczenie: Celem opracowania jest przedstawienie konkretnych przypadków zastosowania geodesignu i partycypatywnego planowania na przykładzie ważnych miejsc kulturowych w stanie Minas Gerais w Brazylii: Pampulha i Iron Quadrangle. Pierwszy przykład to obszar miejski, który ostatnio zdobył uznanie UNESCO dzięki pracom Oscara Niemeyera. Drugi natomiast to region przedstawiający wartość krajobrazową, historyczną i kulturową a dodatkowo bogaty w surowce naturalne (głównie minerały). Wyniki skłaniają do refleksji nad rolą zdolności do współpracy i stosowania wizualizacji w tworzeniu map mentalnych i lepszych warunków dla partycypacji społecznej opartej na metodologii Geodesign.

Słowa kluczowe: geodesign, interoperacyjność, mapy mentalne, planowanie partycypatywne, wizualizacje.

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Why Consultations? The public participation in water management and local spatial planning in two Polish cases

Abstract: Despite many novelties in participation: participatory budgeting, citizens jury, deliberatice poll etc. the engagement of different stakeholders' groups in the decision making processes concerning detailed planning issues (local spatial management plans, water management plans, the preservation management plans of the Natura 2000 sites) is usually based on the organization of open discussion meetings. The study looks at the social consultations regarding acceptance of local spatial management plans managed by Poznań City Hall and consultations concerning the preparation of water management plans managed by Regional Water Management Board in Poznań. The comparative analysis served to exhibit similarities and differences between the processes in terms of legal conditions, the organization of meetings, the length and the scale of the process and the actors engaged.

Keywords: participation, social consultation, stakeholders, water management plans, local spatial plans

Introduction

The growing importance of public participation

Involving citizens and stakeholders in decision making undertaken by the public administrations and agencies has been increasing in last 50 years. Public participation is to promote the deepening of democracy and the legitimacy of actions by authorities. The benefits of participation have been recognized at the international level (World Bank 1996, World Bank 1995) and by individual countries. Engaging the public is widely used in many sectors: spatial planning (Bugs et al. 2010); health care (Abelson et al. 2003); forestry (Buchy and Hoverman 2000); environment protection (Chess and Purcell 1999); nature conservation (Miller-Rushing