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Osvaldo Gervasi · Beniamino Murgante · Sanjay Misra · Chiara Garau · Ivan Blečić · David Taniar · Bernady O. Apduhan · Ana Maria A. C. Rocha · Eufemia Tarantino · Carmelo Maria Torre (Eds.)

Computational Science and Its Applications – ICCSA 2021

21st International Conference
Cagliari, Italy, September 13–16, 2021
Proceedings, Part VI

6 Part VI

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Preface

These 10 volumes (LNCS volumes 12949–12958) consist of the peer-reviewed papers from the 21st International Conference on Computational Science and Its Applications (ICCSA 2021) which took place during September 13–16, 2021. By virtue of the vaccination campaign conducted in various countries around the world, we decided to try a hybrid conference, with some of the delegates attending in person at the University of Cagliari and others attending in virtual mode, reproducing the infrastructure established last year.

This year's edition was a successful continuation of the ICCSA conference series, which was also held as a virtual event in 2020, and previously held in Saint Petersburg, Russia (2019), Melbourne, Australia (2018), Trieste, Italy (2017), Beijing. China (2016), Banff, Canada (2015), Guimaraes, Portugal (2014), Ho Chi Minh City, Vietnam (2013), Salvador, Brazil (2012), Santander, Spain (2011), Fukuoka, Japan (2010), Suwon, South Korea (2009), Perugia, Italy (2008), Kuala Lumpur, Malaysia (2007), Glasgow, UK (2006), Singapore (2005), Assisi, Italy (2004), Montreal, Canada (2003), and (as ICCS) Amsterdam, The Netherlands (2002) and San Francisco, USA (2001).

Computational science is the main pillar of most of the present research on understanding and solving complex problems. It plays a unique role in exploiting innovative ICT technologies and in the development of industrial and commercial applications. The ICCSA conference series provides a venue for researchers and industry practitioners to discuss new ideas, to share complex problems and their solutions, and to shape new trends in computational science.

Apart from the six main conference tracks, ICCSA 2021 also included 52 workshops in various areas of computational sciences, ranging from computational science technologies to specific areas of computational sciences, such as software engineering, security, machine learning and artificial intelligence, blockchain technologies, and applications in many fields. In total, we accepted 494 papers, giving an acceptance rate of 30%, of which 18 papers were short papers and 6 were published open access. We would like to express our appreciation for the workshop chairs and co-chairs for their hard work and dedication.

The success of the ICCSA conference series in general, and of ICCSA 2021 in particular, vitally depends on the support of many people: authors, presenters, participants, keynote speakers, workshop chairs, session chairs, organizing committee members, student volunteers, Program Committee members, advisory committee members, international liaison chairs, reviewers, and others in various roles. We take this opportunity to wholehartedly thank them all.

We also wish to thank Springer for publishing the proceedings, for sponsoring some of the best paper awards, and for their kind assistance and cooperation during the editing process.

We cordially invite you to visit the ICCSA website https://iccsa.org where you can find all the relevant information about this interesting and exciting event.

September 2021

Osvaldo Gervasi
Beniamino Murgante
Sanjay Misra

Welcome Message from the Organizers

COVID-19 has continued to alter our plans for organizing the ICCSA 2021 conference, so although vaccination plans are progressing worldwide, the spread of virus variants still forces us into a period of profound uncertainty. Only a very limited number of participants were able to enjoy the beauty of Sardinia and Cagliari in particular, rediscovering the immense pleasure of meeting again, albeit safely spaced out. The social events, in which we rediscovered the ancient values that abound on this wonderful island and in this city, gave us even more strength and hope for the future. For the management of the virtual part of the conference, we consolidated the methods, organization, and infrastructure of ICCSA 2020.

The technological infrastructure was based on open source software, with the addition of the streaming channels on YouTube. In particular, we used Jitsi (jitsi.org) for videoconferencing, Riot (riot.im) together with Matrix (matrix.org) for chat and ansynchronous communication, and Jibri (github.com/jitsi/jibri) for streaming live sessions to YouTube.

Seven Jitsi servers were set up, one for each parallel session. The participants of the sessions were helped and assisted by eight student volunteers (from the universities of Cagliari, Florence, Perugia, and Bari), who provided technical support and ensured smooth running of the conference proceedings.

The implementation of the software infrastructure and the technical coordination of the volunteers were carried out by Damiano Perri and Marco Simonetti.

Our warmest thanks go to all the student volunteers, to the technical coordinators, and to the development communities of Jitsi, Jibri, Riot, and Matrix, who made their terrific platforms available as open source software.

A big thank you goes to all of the 450 speakers, many of whom showed an enormous collaborative spirit, sometimes participating and presenting at almost prohibitive times of the day, given that the participants of this year's conference came from 58 countries scattered over many time zones of the globe.

Finally, we would like to thank Google for letting us stream all the live events via YouTube. In addition to lightening the load of our Jitsi servers, this allowed us to record the event and to be able to review the most exciting moments of the conference.

Ivan Blečić
Chiara Garau

Organization

ICCSA 2021 was organized by the University of Cagliari (Italy), the University of Perugia (Italy), the University of Basilicata (Italy), Monash University (Australia), Kyushu Sangyo University (Japan), and the University of Minho (Portugal).

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Contents – Part VI

Geodesign Using GISColab Platform: SDI Consumed by WMS and WFS & WPS Protocols in Transformative-Learning Actions in Planning

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Abstract. Territorial planning is undergoing significant transformations that establish as working conditions the use of web-based geospatial technologies, the use of methods for sharing decisions and listening to citizens and the wide use of mechanisms to facilitate understanding due to geovisualization. Among these resources, the methods of planning by Geodesign stand out, which were adapted in the proposal of the web-based platform GISColab, elaborated with the purpose of favoring the shared planning by co-creation. The platform extensively applies the resources of Spatial Data Infrastructures (SDI's) through protocols established by OGC (Open Geospatial Consortium) for consumption of information via WMS (Web Map Service) or WFS (Web Feature Service), allowing in both cases the increment in performances by WPS (Web Processing Service). The article discusses the differences in information consumption and illustrates them through two case studies: Trees for Metropolitan Regions, in which the accesses to data were built by WFS and support to decisions were based on WPS; and Geodesign at Participatory Budgeting where accesses were via WMS. The conclusions indicate the importance of public data being, in fact, of public access and consumption, demonstrating the positive impact of alignment with data exchange protocols. The GISColab platform, developed according to these principles, supports participatory planning, expressively communicative and in transformative-learning actions.

Keywords: Participatory planning · Spatial data infrastructure · OGC protocols

1 Introduction - Contemporary Participatory Planning Based on Geodesign and the Emergency of GISColab

The significant development and propagation of geo-information technology made tools that respond to models of representation, analysis, simulation and proposition of territorial occurrences and conditions, much more accessible to users that need to work with spatial investigation. In truth, these tools facilitate the processes that were previously

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conceived as models in analogical form, when their execution came at great expense. Today they are significantly simpler due to the advent of informatics, thus favoring interesting possibilities for spatial analysis. Exploratory and investigative studies are empowered by geo-visualization resources, allowing involvement of different actors in decision-making and opinion building in shared planning through co-creation.

It has been 50 years since the ideas regarding the "ladder of citizen participation" by Arnstein [1] were first published, and they still motivate and drive urban and territorial planning activity, considering that co-creative planning is a contemporary value that helps to advances mechanisms of participation. The author points out that during the initial stage, comprised of the first two steps of the ladder, citizens are manipulated and falsely convinced of their participation, in what she defines as "therapy". During the second stage, composed of three steps, appeasement is sought as the participants are offered information and some inquiry is made, though limited to the appeasing process. On the third stage, also composed of three steps, citizens achieve some degree of power, as partnerships are suggested, some autonomy is delegated and, at last, citizens have some control over results. Among many publications developed from the initial proposal, it´s interesting to mention Rocha's [2] work, arguing for the expansion of studies on the "ladder of empowerment", understood as a contemporary variation of the participation model defended from the 1980's onward [3–6]. Based on the elements of locus, process, goals and power experience, Rocha [2] defines a new 5 step ladder, which include atomistic individual empowerment, embedded individual empowerment, mediated empowerment, social-political empowerment, and political empowerment. The development of the process starts by altering one's individual conditions until it is possible to alter the general conditions of an entire society. Since it creates an increasingly wider approach, the author emphasizes a growing pattern between each stage, so all levels need to be stimulated and worked on.

It is important to note that although both authors refer to this process as a "ladder", this does not necessarily mean one step is less important than the other, or that it should be an error or mistake that was overcome by advancing to the next one. For instance, informing citizens is part of Arnstein's [1] step 3, which does not mean it has to be abandoned, surpassed or anything along these lines. In our understanding, there are keywords and values that need to continue to exist for participation to evolve and indeed become socially beneficial as it expands planning capacity. They include the need to: inform, consult, promote partnerships, conscious delegation of tasks, favor individual improvement, mediate collective actions, and achieve political development by understanding that collective agreements are a way to maximize consensus.

One may state, as proposed by Innes [7], that the 1990's saw the emergence of a line of thought that defends interactive planning as a communicational activity, incorporating communities, political issues and public decision-making processes. To understand the context surrounding this idea, Khakee [8] presents an axial planning structure that ranges from the approaches of Rational-Comprehensive Planning; Incremental Planning, Advocacy Planning, Implementation-Oriented Planning, Strategic planning, Transactive or Participatory Planning, Negotiative Planning and Communicative Planning.

In the Rational-Comprehensive approach, the planner decomposes reality to its individual components in order to interpret them. This results in a hierarchical matrix with the actions that are limited to the political and technical spheres, which does not include citizen participation. The Incremental Approach consists of facing only the most important issues and to seek small, incremental changes, wherein community role is taken into consideration, but as information providers. The Advocacy Planning approach proposes that populations are heard through different groups that represent society, and when there are no groups capable of representing certain sectors, their interests would be defended by planners. Implementation-Oriented focuses on discussing processes in a way that guarantees that the planning is executed and is not limited to an analytical portrayal of the problems. Strategic Planning argues for the substitution of proposed solutions for a given set of commitments, and in doing so, includes the participation of the population and the search for consensus among actors in the different stages of planning. Transactive or Participatory planning suggests an association between technicians and citizens, which imposed the need for planners to have skills related to communication and social psychology, since their role would be that of a mediator for social and urban changes. Negotiative Planning is based on creating mutual agreements and commitments, which involves citizens, companies, and public authorities. At last, Communicative Planning defends each process is unique and specific to each situation, and that planners are non-neutral elements of this process, though they should commit to building consensus amongst participants [9–12].

As is the case when analyzing the ladder of participation and the ladder of empowerment, one needs to understand that even though each new form of planning emerges from criticisms to previous processes, a lot of these proposed actions and modes of planning still play a fundamental role and should not be promptly discarded. The Advocative position should be limited to how the planner acts to decode the collective will, an ability that may be developed by methodical processes for hearing and mediating, which leads us to the proposals made by Transactive Planning. The Strategic Approach can continue to exist by building consensus regarding the priorities of each proposal, which are built collectively. Negotiative Planning is based on the maximization of consensus, in which the demands and concessions are clearly defined. The focus on building consensus is still present in Communicative Planning, which clearly states there is no single path, but rather that each case is unique in its requirements, as argued by Forester [13], who describes it as a process of "Transformative Learning".

In face of the values and demands imposed by contemporary reality, one of the methods that planners can resort to is Geodesign, as it is based on the creation of workshops that bring together different social actors. Geodesign is design "with" and "for" the territory. It seeks a contextualized transformation of landscapes, respecting nature and local culture. Geodesign can provide a systematic methodological model for regional, urban and local planning, aiming towards the sustainable integration of human activities within natural environments, respecting of cultural peculiarities and allowing for a democratic decision-making process.

It is a method for the collective construction of alternative futures for a given landscape or territory, applicable in any scale and in which listening to citizens is crucial for building opinions and making decisions. It is widely supported by geovisualization platforms. The basic principle is to inform participants of the essential characteristics of the area, and to do so it is necessary to provide a set of thematic information, as well as synthesizing them into the main systems, which will become the basis for the co-creation of policies and projects.

Different authors have discussed the concepts and work models used in Geodesign [14–18]. Starting from a common conceptual base, each researcher builds their own framework, which is practically a matter of producing data and information regarding the area's current conditions, followed by participants visualizing and interpreting the information. After this stage, representatives from different sectors of society are asked to collectively build proposals for projects and policies that aim to transform the area, thus reflecting upon its alternative futures. The ideas that are formulated by each group are confronted and analyzed in terms of their impact and proposed goals, to finally achieve a final design by approximating consensuses.

Considering the classification scheme of Khakee [8], we believe the proposal of Geodesign was planned to be more associated to Transactive or Participatory planning, since the role of the conductor was expected to be that of a mediator for social and urban changes and, as the term specifies, a "mediator". But in some cases, it´s based on significant interference of the conducting agent in classifying the areas that can receive proposals, determining which impacts are positive or negative, establishing goals (targets). If the process is well conducted, the organizer will act facilitating negotiations as a mediator. But it depends on the framework and on the tools employed.

The principles of Geodesign were adopted in the GISColab web-platform, developed by the of Geoprocessing Laboratory of Architecture School, Federal University of Minas Gerais, Brazil: Prof. Ana Clara Moura and Christian Freitas. The platform is sufficiently flexible to be used according to the itineraries required for each case study. GISColab's Geodesign practices are also based on Transactive or Participatory Planning, but it goes further, due to significantly advances Communicative Planning, since the platform can be adapted to include different frameworks and provide proper support to the information required by each case study, thus favoring a fully "Transformative Learning" process.

Through GISColab, we advocate for sharing a systematic analysis of territories, but also to include citizen's views as a way to provide more information, in a process we named "Reading Enrichment", In which citizens inform themselves through a collection of data organized by specialists' knowledge, then contribute with their own information and analysis of existing conditions, not necessarily in this order, but organized according to dynamic processes. We defend widespread access to information to avoid reductionist syntheses that end up conditioning decisions, since each social group can choose their own scope and indicate it as appropriate or inappropriate for a specific condition. Therefore, information is provided in a way that is flexible enough not to be supported solely by variables, but rather in "Contexts", and allow participants to create analytical and synthetic compositions according to their own interests.

In GISColab, participants develop and register ideas that are subject to discussions in the form of "Dialogs", and there is no pre-established definition of "right or wrong", nor positive or negative impact, but rather a sum of comments that stimulate individual decision-making. This process can be associated to the principle of "Actionable Consensus", as proposed by Healy [19].

GISColab's Geodesign process can be conducted by planners according to a freely established itinerary, favoring co-design and co-creation. However, the right to make individual remarks and register a vote are guaranteed by registering them in “Dialogs” and by using the “Like or Don’t Like” resource. It bears noting Friedman’s [20] emphasis that the planner’s goal cannot be limited to “getting to a yes”, since planning is not necessarily a decision, as it can also be the starting point for building opinions and understandings regarding the territory. Planning can be a support to decision making or a support to opinion making. It is also necessary to invoke Sandercock’s [21] warning that, in planning, there is always some risk regarding the ability of each social group to affect planning outcomes, though this can take place even in a local scale, when a group includes individuals who control the speaking and, ultimately, the decisions that are made. In that sense, individual participation is also promoted in our process, but in balance with group participation.

We would like to stress that GISColab planners can orchestrate the dynamics of discussion and collective idea-building according to their own judgment, freely defining their work itinerary, because the platform is quite flexible and open to the development of scripts that take specific actions. For instance, calculating goals, defining scores, creating a voting hierarchy, performance board and any other forms that support the visualization of information deemed relevant. These are done through the “Dashboards” or “Widgets”, or calculations done during the integration with data bases on a web server. Hence, there is no “right” or “wrong” in how the tool will support planning because there are several possible ways to adapt it, even during a workshop, as one realizes that planning should be kept flexible, evolutionary, and dynamic.

It is our belief that Geodesign, and its application in the form of GISColab, is a relevant response to contemporary challenges, in which planners can take collective will into account and build co-designed proposals through active listening and citizen participation. Therefore, advancing a process that reduces urban planners’ role as authors and amplifies their role as decoders of collective will [22].

2 Methodology - The Proposal of GISColab

According to a new line of thought within information technology, named SOA - Service Oriented Architecture [23], the constant use of the Internet in the contemporary world constitutes an infrastructure in which systems are intrinsically connected and in co-dependence. Such technologies are at the foundation of SDI - Spatial Data Infrastructure, proposed by the Mapping Science Committee of the US National Research Council in 1993, and incorporated by INSPIRE (Infrastructure for Spatial Information in Europe) in 2007 [24].

In Brazil, the intention of providing resources on spatial data infrastructure was registered on Decree 6.666 of November 27h, 2008, published by the Ministry of Planning, in which the National Spatial Data Infrastructure was officially created. It was expected that this principle would also be transplanted into state and city scales, fostering and facilitating the access and consumption of geographic information. In order to fully provide access to information, it would be necessary to take interoperable aspects into consideration, which would translate into an effort towards the standardization, sharing and integration of geospatial data.

To achieve interoperability, the OGC (Open Geospatial Consortium) developed a specification for mapping on the web, which is based on a non-proprietary system, thus allowing users to consume data regardless of the software they use [25]. Geographic data consumption uses the WMS (Web Map Service - OpenGIS Web Map Serive Interface Standard), WFS (Web Feature Service - OpenGIS Web Feature Service Interface Standard) and WMTS (Web Map Tile Service) standards and can also be incremented with WPS (Web Processing Service).

OpenGIS® Web Map Service Interface Standard (WMS) offers a simple HTTP interface for requesting images from the georeferenced map and one or more databases. A WMS request defines the geographic layer and area of interest for processing. Specifications include at least three different contents in response to the user's request: a) metadata; b) the map with the specified geographic parameters and c) information regarding some specific feature presented on the map [26].

The OpenGIS® Web Feature Service Interface Standard (WFS) also allows the exchange of geographical information through HTTP protocols in GML language. Geographic Markup Language (GML) is a standardized XML language that provides a specialized vocabulary for working with geospatial data. The GML language allows the codification of geographic characteristics beyond modeling, transportation and storing geographical data, in different vectorial and matrix formats [27].

In line with OGC proposals, the GISColab Platform can be described in terms of 4 technological components that, albeit distinct, are complementary:

(a) Geographic Base - The collection of information produced that can be stored in BDG, Shapefile for vector-type information and GeoTIFF for raster-type data.
(b) Geoserver Map Server - The map Server is responsible for converting geographical information into webservices, making the distribution of data more dynamic and guaranteeing interoperability. (Geoserver - http://geoserver.org/ - a Java-based server that allows users to visualize and edit geospatial data. Using open standards established by the OGC).
(c) Metadata Catalog - The metadata catalog Server is responsible for documenting all the information produced that will be used in decision-making and spatial analysis processes. It plays the crucial role of formalizing and registering the spatial set that was used as data for the decision making, as well as the information produced by reading and analyzing basic information. (Geonetwork - https://geonetwork-opensource.org/ - a catalog application for managing spatially georeferenced resources. Currently, it is used in several spatial data infrastructure across the globe).
(d) WebMap/WebGIS - WebGIS is responsible for retrieval and visualization of information registered in the metadata catalog, as well as organizing information in way that provides a better context for the data and groups of data. Moreover, complementary resources were developed, which allow it to be used for Geodesign and processes of shared decision making. (Mapstore2 - https://mapstore2.readthedocs.io/en/user_docs/ - WebGIS software that is highly modular and open-sourced, developed by GeoSolutions to create, manage, and share maps/panels in a more secure manner).

3 Two Case Studies Conducted in GISColab: With WFS, WMS and WPS Support

In virtue of the limitations imposed by remote work during the 2020–2021 COVID pandemic, the Geoprocessing Laboratory from Architecture School of UFMG, had to develop and test new capacities for conducting Geodesign workshops in a completely remote mode. These challenges resulted in the expansion of the GISColab facilitation tools and the collaboration of different groups, leading to the creation of a study network.

A group consisting of 14 Brazilian universities came together in order to test a single Geodesign protocol for the subject "Trees for Metropolitan Regions", according to the guidelines defined by the IGC global group [28]. It emphasized the creation of mechanisms for characterizing, measuring and incrementing carbon sequestration, with the goal of reducing global climate change. The universities involved and their respective metropolitan areas (MA) were: Universidade Federal do Pará (Belém MA), Universidade Federal de Minas Gerais (Belo Horizonte MA), Universidade do Estado de São Paulo campus Rio Claro and Universidade de Campinas (Campinas MA), Universidade do Extremo Sul Catarinense (Carbonífera MA), Universidade do Estado de Santa Catarina (Florianópolis MA), Universidade Federal do Ceará (Fortaleza MA), Universidade Federal de Goiás (Goiânia MA), Universidade Federal do Amapá e Secretarias do Estado do Governo do Amapá (Macapá MA), Universidade Federal de Tocantins (Palmas MA), Universidade Federal de Pernambuco (Recife MA), Universidade Federal Rural do Rio de Janeiro and Universidade Federal de Juiz de Fora (Rio de Janeiro MA), Universidade do Estado de São Paulo (São Paulo MA).

Before the pandemic, a workshop associated with the subject of Participatory Budgeting was already planned, as part of Ana Isabel Anastasia de Sá doctoral work, using Belo Horizonte as a case study. The initial idea was to conduct the workshop on the university's computer labs, which would privilege in-person discussions. However, the restrictions imposed by the pandemic made the workshop much closer to what would be desirable for a shared planning that involved a broader group of social actors, facilitated by Internet access, although it is necessary to recognize the difficulties of the digital access inequalities. But the possibility for wider diffusion of information in this case is something worth highlighting. The workshop was conducted by the doctoral candidate, with support from the Geoprocessing Laboratory from Architecture School of UFMG team and the participation of academics, people from different city regions and technicians from the Belo Horizonte town administration.

The case study on the Metropolitan Regions presents is an example of a workshop in which the assembly of data and access to WebGis was based on the usage of data from the (SDI) (Spatial Data Infrastructure) platform via WFS (Web Feature Service). The process requires structuring a database of geospatial data, based on the exchange of information through HTTP protocols in GML (Geographic Markup Language), a standardized XML language that provides a vocabulary specific for working with this type of spatial data.

The case study on Participatory Budgeting is also an example of a workshop in which the WebGIS assembly provides support to the overall process, consuming data via WMS (Web Map Service) and connected the layers through a Service Catalog that seeks the URL (Uniform Resource Locator).

3.1 Brazilian Geodesign: Trees for Metropolitan Regions

The development of 12 parallel case studies encompassing Brazilian's metropolitan regions, meant it was necessary to establish a set of standard practices for the processes, thus allowing comparative studies on their performance. The Geoprocessing Laboratory from Architecture School of UFMG was put in charge of producing the entire collection of data for all the case studies, guaranteeing all work was performed under a shared, common ground. Moreover, it intended to show that the process was scalable and could be reproduced in other locations in Brazil to perform regional scale planning.

The starting point included the 10 systems proposed by the IGC-2021 group regarding that year's experiment, namely: vegetation, hydrography, habitation, transportation, institutions, industry and commerce, agriculture, energy, tourism and culture, carbon credit. The first 8 were defined by IGC-2021's project, which left two other systems open for participants to choose. Brazil chose tourism, leisure and culture, due to its national importance, and carbon credits sequestration after a specific study was conducted, to discuss the subject in terms of metropolitan regions. The first step was to define the minimum data and which analyses would provide support for understanding the 10 systems, and a list comprised of 42 maps was produced.

A total of 18 data platforms were consulted to produce theses maps or acquiring the necessary information. This is because the national SDI platform (INDE - Infraestrutura de Dados Espaciais), despite being used for most of the information layers, did not contain all necessary data for the systems included in the workshop. Three of these 18 platforms were international ones (two of them for acquiring satellite images to vegetation classification indexes and surface temperature, topographic images for the calculation of slope inclination and altimetry and one for collaborative data). It is worth noting that a lot of the available platforms have IDE characteristics, but since they do not fully attend the conditions and standards defined by the norm, they may not be classified as complete IDEs. However, for the purpose of this work, they were considered as such, given that they are storages of publicly available geospatial data. From the 15 national platforms, 13 of them were of national character, 1 of them was for a specific portion of the country and 1 was for state-level data.

None of the platforms provided WMS data consumption, or the access format did not fully adhere to OGC standards, which would mean using a link for direct consumption of the layer in the form of an entry on GISColab's Web-GIS. The main national platform in Brazil, INDE, does not provide information via WMS, but we can consume data by downloads. Minas Gerais' data infrastructure (SISEMA) does not provide WMS access but also does offer some downloads. The issue is that even though some platforms provide some sort of WMS access, we are not able to use the data as the basis for the layers used on applications if they are not completely compatible with OGC standards.

Given the inability to make a direct use of the data via WMS, we opted for the longer work involved in using it via WFS, in which we need to download and upload as we tweak the data to fit their more specific purposes. This includes standardizing captions, symbols, or the application of distribution models and spatial analysis. Therefore, the layer acquires some degree of authorship, although the origins of the data are clearly defined. Out of 42 layers, 21 were subject to a process of cropping for defining the area of analysis, projection, grouping captions to suit our goals and standardizing them. However, 21 of them were the product of spatial analysis models based on activity concentration (weighted kernel); hierarchical classification (alpha-numeric table associated with a cartographic base); definition of areas according to normative parameters (buffers); thematic creation using altimetry, slope inclination, isolation, surface temperature; algorithm application (NDVI); calculation of metrics (landscape ecology).

It should be noted that, for this case study, WPS (Web Processing Service) resources were used in widgets, which were programmed to provide a dynamic visualization of automated calculations during the workshop. The study was centered on a discussion regarding carbon sequestration and credits, and the request was that participants created proposals for conservation, creation and extension of areas for the recovery of CO2 emissions. During this process, as participants created polygons related to these ideas, their areas were computed and the percentage increase in carbon sequestration was also computed and calculated to check if the goal of 30% of increasement was achieved, what was the number of trees that resulted from the increment in areas, the amount of CO2 in MgC above or below surface and the size of the area in km^2. The processing stage acted as a dynamic support for decisions [29] (Fig. 1).

As part of the analyzes proposed by the IGC, there was also the analysis of the proposals created by the participants and their contribution to the SDGs. In the first case studies, the coordinators carried out this assessment after the creation of the proposals, observing and suggesting which of the SDGs each idea could contribute to, and filling in a spreadsheet with the evaluation of the contributions. During the development of the workshops, we observed that it would be more interesting for the author of the proposal to indicate, in his opinion, to which SDG his idea could contribute, and for the system to calculate and present the sum of the contributions. For this, it was programmed a dynamic layer using WPS, which searches for the data of the ideas created and presents a graph in a widget indicating on the x axis the list of the SDGs and on the y axis the quantity of ideas associated with each objective. This is a way to monitor how each objective is being met by the participants (Fig. 2).

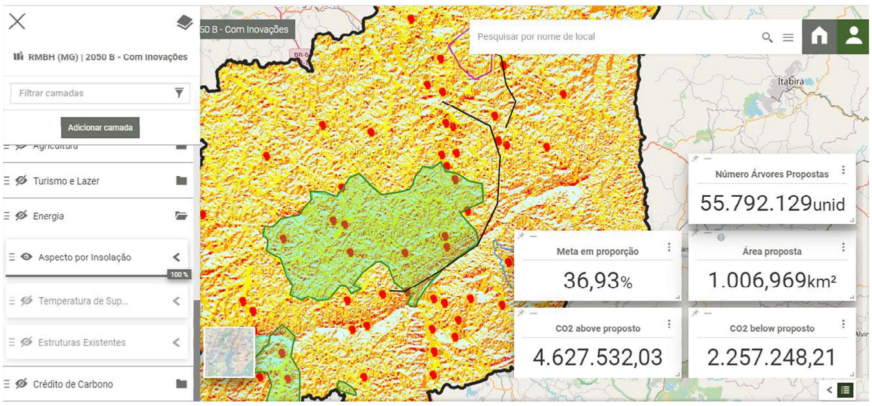

Fig. 1. Belo Horizonte M Region example: the use of WFS and WPS. Source: The authors.

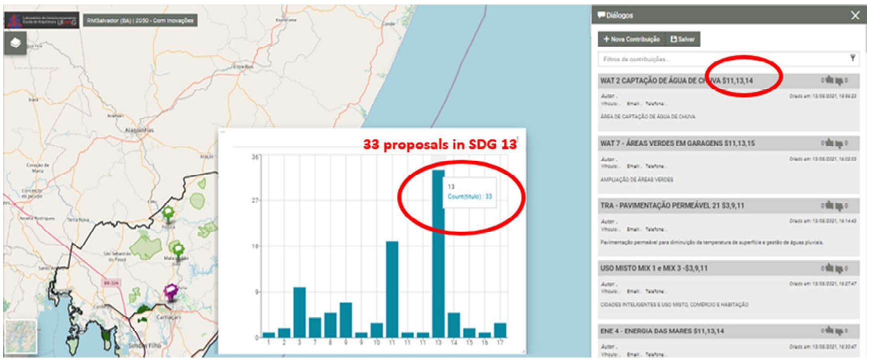

Fig. 2. Salvador M Region example: the use of WPS to SDGs' analysis. Source: The authors.

The advantage of working with WFS access is that the organizer creates the information layers and adapts them to the specific needs of the research. However, this does require special knowledge in data modeling and geoprocessing. An experienced researcher will need, on average, 36 h of work to prepare the 42 layers, 4 h to structure the server database and 4 h to set up WebGIS and geovisualization. This adds up to an average of one hour per layer. If it were possible to access the data via WMS, the stages of preparing and structuring the database on the server would be mitigated, leaving only the need to address layers via URL on WebGIS, and thus reducing average work hours to around six to ten minutes per layer once its web address has been identified.

3.2 Participatory Budgeting: Sharing Decisions in City Planning

The employment of Participatory Budgeting (PB) gained worldwide notoriety in urban planning after the second UN-Habitat meeting in Istanbul (Turkey), 1996, and became something of particular interest in Brazil after the World Social Forum held in Porto Alegre, in 2001 [30]. However, both the interest and the results produced by this practice have declined in virtue of their quality, not to mention that they became mostly consultive instruments, which are not really open to shared planning.

The current study, a simulation of a public query on resource distribution via PB using the Geodesign method and GISColab platform, had the goal of avoiding the existing pattern of previous queries in Belo Horizonte, which had a predominantly consultive nature, and sought instead to test the creation of collective ideas via digital processes.

Participatory budgeting was first implemented in Belo Horizonte in 1994. Up until 1999, PB took place annually, and became bi-annual since. The Digital Participatory Budget was implemented in 2006 and took place four times after, in the years of 2006, 2008, 2011 and 2013. The process was expected to increase general participation, including groups that would generally not take part on in-person meetings. Notwithstanding, parallel processes with in-person discussions for regional areas were kept, and digital PB was conducted in a fully on-line environment. In 2006, there was an attempt to integrate these processes, with proposals being discussed in-person and voting taking place in a broader, digital way. Leading up to 2006, around 10% of the population would participate in these votes, an amount that fell to 0.4% by 2013 [31].

According to Avritzer [32], the expectation was to balance the articulation of representative and participatory democracies by providing equal participation and deliberation power to all citizens. However, what was observed is that the Advocative Planning pattern was maintained, with the technical board accounting for different social groups, and little advance towards Transitive or Participatory Planning, let alone Communicational Planning.

Perhaps the issue, as pointed by Souza [33], is that a cautious and instrumental approach was not the one that guided PBs, but rather a view that sought to increase political consciousness and reform social and political systems through collective action. Hence, Ana Isabel Anastasia de Sá doctoral work had an interest in experimenting with Geodesign's approach, in which the method or itinerary must be clearly presented as the central axis of the participants' co-creation process. Also, to experiment with the Brazilian GISColab platform and the flexibility it provides for adopting different work itineraries.

GISColab can receive data by preparing and uploading the layers chosen by the coordinator, who will develop maps via geoprocessing and symbol application, structured as a WebGIS (Geographic Information System that is transmitted and accessed through the web). However, one of the key potentials uses of the tool is the ability to consume data via WMS, a process in which it will directly connect to an SDI (Spatial Data Infrastructure) and directly access the available maps, without the need for further preparation, but receiving the symbols as the original [34].

There are still few SDI platforms in Brazil which allow WMS access to data, but it is worth mentioning that this possibility is what truly makes SDI a public service. For studies in the Belo Horizonte municipality the local SDI, BHMaps [35], was conceived entirely within OGC standards, and based on WMS. This favors an approach in which workshop organizers define only the information layers that are considered of interest and load them up via their URL.

The reason for using a database which, in turn, uses existing layers is that we wanted to maintain a language that has already been shared by users (BHMaps is already known as Belo Horizonte's information platform). The expectation is that this would help participants understand the area and allow them to dedicate themselves to creating proposals. The visualization symbols (captions and their graphic rendering) are inherited from the original layers, which is another way of maintaining the connection to the data that users are already familiar with.

However, BHMaps has hundreds of layers organized in 29 main themes, which could lead to a sort of information maze if they were entirely consumed. Hence, the organizer had to make a strategic choice regarding the most relevant layers, 69 in total, with users being allowed to include new layers as they deemed necessary.

The maps were organized according to the main themes that impact PB decisions, or that are generally dealt with in PB proposals, namely: social welfare, culture and tourism, education, sports and leisure, habitation, environment, public squares, mobility and transportation, health, demographics, land division, urban legislation, soil usage and occupation, infrastructure, urban cleaning, slope inclinations, economic activity, free access to internet, and risk (Fig. 3).

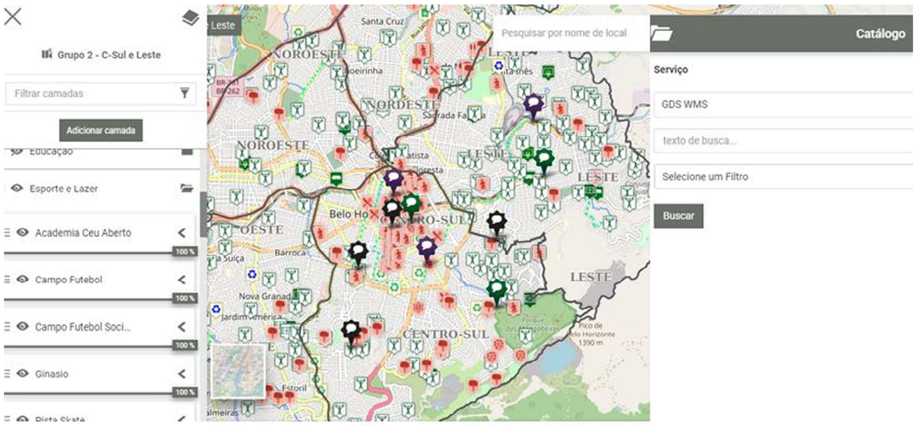

Fig. 3. Participatory budgeting in Belo Horizonte: the use of WMS. Source: The authors.

GISColab's Geodesign process followed the stages of "Reading Enrichment", in which participants inform themselves and register information through map layers, including the area conditions, registering alerts on potential uses, vulnerabilities, specific characteristics of the territory that they would like to highlight for consideration in proposals. The second stage, the "Idea Proposition", comprises participants' coming up with their own ideas, though it is possible to exchange thoughts with the remaining participants through videoconferencing, so ideas can emerge from either individual citizens or as a collective effort by a group. On the third stage all ideas are commented on, in the "Dialogs" process, so that they can be subject to questioning, gain support, have further information added to them or receive requests for additional information. In the final stage, the "Voting", they voted on each idea and a hierarchy is set according to the amount of "likes" received and the limits imposed by financial resources, given that they are also scored based on their cost range.

4 Results and Conclusions

The first consideration advanced by this paper regards the role of Geodesign, developed through the GISColab platform, as a methodological support for the development of participatory planning according to contemporary values. There are various publications regarding the processes of Geodesign, in which authors present their work structures as itineraries, mostly through standard scripts that are portrayed as applicable to different case studies. The studies that are made possible by using GISColab do not start from a pre-fixated protocol, but rather have the necessary flexibility to allow for adaptations even during the workshop, in virtue of the specific needs of each group, territory, set of goals. However, that requires the planner not to act as an author of the project, but rather as someone who decodifies the collective will [22]. To do so, it is worth noting the approach Khakee [8] classified as Transactive or Participatory planning, in which the orchestrator needs to have communicational skills and be able to achieve a sort of psychological pairing with participants, to know the right moment to propose specific resources and procedures.

The work itinerary that was most tested in GISColab and adopted in the two case studies portrayed in this paper, albeit with some occasional differences and adaptations made to better serve different purposes, was the one that initiates with "Reading Enrichment", with the goal of informing participants and collecting their information regarding the territory. This stage is followed by "Idea Proposition", which can take place in synchronous or asynchronous processes, and in which dynamic tools provide a significant support by offering participants feedback on quantitative data, goals, percentages, comparisons. In that sense, such support is in line with the principles of the planning typology defined by Khakee [8] as Strategic planning, since a few sets of expectations or principles can be established to create agreements.

In the case study Trees for Metropolitan Regions, an expectation for increments in carbon sequestration was established, expanding areas with robust vegetation by 30% until 2050, a value that is supported by bibliographic reference. This was achieved by implementing dynamic calculations that would compute the performance of each proposal and present partial results on widgets. In the Participatory Budgeting case study, the mechanisms used were voting and score calculation, based on the costs of each proposal and the limits of the budget, which were used to create a hierarchy.

Once the ideas are proposed, the "Dialogs" mechanism has been widely used. In it, participants can comment, question, complement or defend the ideas that are portrayed, so that they are not left in isolation, but rather interpreted as part of a context and eventually, even be improved through collective co-design. Therefore, this stage of the planning can be classified, according to Khakee's [8] model, as Communicative, because it is a way to articulate and favor the achievement of maximum consensus, with ample hearing and the right to individual manifestations.

At last, since the platform is open to WPS programming, it can receive additional data that is deemed relevant by participants via WMS or WFS, at any given stage. Thus, participants can take control over the set of information and perform individual judgments regarding which areas they consider apt or inapt for intervention, areas that are or are not in need of new uses, or if it is indicated for new ideas or not. In such sense, it allows for a type of planning that Forester [13] classified as "Transformative-Learning".

Finally, a discussion is due regarding consumption expectations and the use of geospatial information in web-based platforms that support planning. For participants to use information that is already publicly available, we highlight the importance of SDI platforms that adopt WMS standards plus OGC precepts. However, there is the risk that this kind of spatial data usage creates an exponential demand in data server infrastructure, since the more useful the platform, the more other platforms will be connected to it. From a planning point of view, the interest and the growth in use are incredibly positive factors, since they remove data from a state of stale information and place them as the basis from processes that transform society. The issue of scalability, though, is something to be reckoned with. The technology to solve this problem is already available, for instance by employing WMTS (Web Map Tile Service), which facilitates map consumption by pre-rendering the layers that will be visualized in a faster and optimized manner.

This does not mean that the importance of WFS geospatial data consumption should be understated, since they allow the planner to work with the geovisualization of information to favor strategies and create alerts for participants. Nonetheless, one must need to be prepared to face significant demands of time and expert knowledge regarding geoprocessing to prepare the layers that will serve as foundation for the workshop.

In both cases, between the consumption of spatial data via WMS, WFS or WMTS, the potential of WPS must be noted when it comes to the production of dynamic data that fulfills the strategic goals of information consumption in decision making processes. Some keywords will define the development of tools that support planning, and Geodesign specifically: scalability, flexibility, geovisualization.

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