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Geodesign as a support for proposing actions to fulfil the Sustainable Development Goals

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Abstract:

This paper discusses the state of the art in Geodesign, as a result from the evolution in the use of geospatial data for shared and co-creative planning. The evolution of Geographic Information Systems (GIS) led to significant advances in geovisualization, the use of cartographic data via the Internet and the construction of SDIs (Spatial Data Infrastructures). These advances fostered the emergence of Geodesign as one of the foundations for territorial planning. The text will also introduce a Brazilian Geodesign platform, GISColab, developed according to the standards set by the Open Geospatial Consortium (OGC). The platform introduces layer creation resources via WPS (Web Processing Service), as well as tools for measuring the performance of participatory planning workshops, presently focusing on the UN's Sustainable Development Goals (SDGs). We introduce case studies in which SDGs were explored in different ways: in post-workshop analyses conducted by coordinators and participants, as well as its application as a supportive tool for decision-making during the workshop, via WPS. Finally, we also discuss the inclusion of SDGs to raise awareness of its key themes and support opinion building, resulting in transformative learning experiences.

Keywords: SDI (Spatial Data Infrastructure), WebGIS, OGC (Open Geospatial Consortium)

1. Introduction

Cartography is the science of representing the Earth, associating an artistic component (a representation of culture according to its ways of seeing the world) with a technical one, that is, the ability to capture and display spatial information. Thus, cartographic science is intimately related to the technological and methodological evolution of humankind, while it also works as a representation of the values and ideas of a given epoch. The analysis of cartographic production, alongside Geography, is a way to understand how each period of human history would think about spatial relations. It is worth noting that spatial issues have never been as present as today, where nearly everything is georeferenced and guided by "where" and "when". In technological terms, this translates into the ability to use people as sources of data, which relates to the concept of citizens as sensors (Goodchild, 2007).

The evolution in the use of cartography as part of everyday life starts with Geographic Information System (GIS), as they expand our ability to store and distribute information. The role of GIS was particularly amplified with the Internet, which allowed geographic information to underline most of the information consumed in a global scale, in recent times. This gives prominence to geospatial information and geospatial sciences, which become part of the lives of everyday citizens, and naturally, the foundation for participatory planning processes and collective decision-making.

When analysing the evolution of GIS, Cowen (1990) argues that they went through different stages, namely: a "database approach", "toolbox approach", "application approach", and "process-oriented approach". The author proposes that the database approach fulfilled the goal of developing data gathering processes, while also improving the distribution of geographic information. The toolbox period stimulated the development of algorithms capable of combining data to transform them into usable information, resulting in spatial analysis models. The application stage facilitated users' access to data, while also building an association between geographic thinking and geospatial methodologies to create real-world applications of its logic. At last, the process-oriented approach further explored the possibilities for the creation of frameworks that were based on the logic of planning systems that were used in other fields.

Within this evolution, GIS progressively transformed data into information and information into knowledge, achieving gains in the technological, methodological, and user-related fields. GISs are no longer available only to experts but are now part of everyday life. In that sense, studies in Planning Support Systems (PSS) were structured according to frameworks that had clear parameters for defining its agents, stages, tasks, and goals

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to be achieved. According to Harris & Batty (1993) and Geertman (2008), PSSs are built to approach complex issues, associating elements from the systemic approach and principles of GIS models and visualization. In the case of PSSs based on geographic studies, Geovisualization. By including citizens into its agents, PSSs also support collaborative processes (Klosterman, 1999).

Special attention must be given to the evolution of geovisualization within cartography and GIS. Geovisualization is the amplification of the principles of visualization for spatial sciences, according to the specific principles of spatial information. According to McCormick et al. (1987) the improvement of visualization should be defined with the goal to “see the unseen” trough choices regarding the main components, form of representation and utilization of these elements by users. It is a way to reveal what is not yet perceived, that which may be present but needs to be more clearly identified. MacEachren (2004) argues that this process involves going through the following stages: presenting the information, constructing a mental synthesis, analyse the existing elements and, at last, constructing knowledge. As a result, if cartographic information is well developed and presented to users, it allows them to build further knowledge of the territory, which is the first stage of a participatory planning process. Cartography, as a field that promotes knowledge of the territory, allows it to act as a common language, integrating the different agents that participate in shared planning processes (Zhou et al., 2002). The term territory, in that sense, is defined according to the principles presented by Dematteis and Giverna (2005), because it is constituted by the relationship between the social and the environmental, as the object of dispute and productive relationships. This concept is at the heart of shared planning.

1.1 The emergence of Geodesign

It is natural that changes in spatial planning take place in view of the wider access and production of geographic data, given the significant transformations produced by the Internet and the inclusion of geospatial principles into everyday life, not to mention the developments it provided in terms of geovisualization. In recent times, these planning processes have been associated to the term “geodesign”, which according to Dangermon (2009) is an idea that is as old as it is new.

Li et al (2010) and Steinitz (2010) define Geodesign to design “with” and “for” geography. According to Steinitz (2010), the term was initially used in this sense in 2008, at the NCGIA Specialists Meeting on Spatial Concepts and GIS and Design, to refer to the act of sketching ideas for an area using geographic information as a support. However, Miller (2012) reveals that the word had already been used, in a slightly different sense, by Klaus Kunzmann (1993), in the paper “Geodesign: chance oder gefahr?”, to refer to spatial scenarios, which is like the approach used by MacHard (1969). Other authors argue that Geodesign is a continuation and expansion of the proposals that were initially presented by McHarg in “Design with Nature” (1969), which were based on the combination of variables to develop spatial analyses, indicating areas with potentials and vulnerabilities.

The wider sense of the term Geodesign in contemporary times is due to the fact it goes beyond analysis and moves into the propositional stage, the realm of landscape design (Dangermond, 2009; Ervin, 2011; Miller, 2012). Flaxman (2010) defends the idea that Geodesign is an approach that surpasses conventional methods due to its ability to propose, test, evaluate and share a design in real time, using a database that is expressed through geospatial technologies. In that sense, there are authors such as Wilson (2015) who would call this process "Critical GIS” instead of Geodesign, because it is an expanded and improved use of geospatial information.

Frameworks are proposed for shared planning, in a co-creative manner, using GIS-based cartography via the web, which is then optimized by geovisualization. The Geodesign application framework developed by Li et al (2012) is based on the stages of: applying group engagement methods in the initial stages of the process; consensus-building methods that involve the specification of values for different proposals; spatial analysis methods to simulate possible conditions and impacts; project management methods to achieve a final decision.

Miller (2012) indicates that a Geodesign approach can be developed according to a science-based design, value-based design or integral, or holistic, design. In a science-based design, proposals (conceived as geographic entities/features) respond to the scientific information used in their creation (georeferenced information). Within value-based design, proposals for new geographic entities (the ones being planned) respond to the social values that are relevant to its creation, installation, or use (identified by its georeferenced data). The principle of integral or holistic design results in new geographic entities (proposals) that respond to the definitions of science and local values, but also multidisciplinary issues which, according to the author, can be used to solve the conflicts that emerge within the previous approaches.

In Steinitz’s (20120) view, the framework of Geodesign involves going through three iterations of a six-model process, which is repeated. These iterations respond to issues regarding their “what” (understanding the area of study), “how” (define and adjust the work methodology using the experiences of the previous iteration) and “where, what, when”, to reach a final decision on the design. Furthermore, in each iteration, six models are used, respectively: a) Representation model (present data on the area of study); b) Process Model (inform on the spatial occurrences within the data); c) Evaluation Model (evaluate if the area is functioning properly, indicating potentialities and vulnerabilities); d) Change Model (present ideas for projects and policies); e) Impact Model (evaluate the possible impact of these proposals); f) Decision Model (agents negotiate a final design proposal).

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Ervin (2016) lays out a framework developed in consideration of landscape architecture. The author writes that the process is a cycle, which undergoes three stages, based on abstract principles, and three more, based on concrete ones. It starts with two concrete stages: a) “habitation” in the sense of existing, b) the perception and measurement of existing reality. These are followed by three abstract stages: c) analyse needs and define objectives; d) create the design in response to the needs; e) communication and representation. At last, the final stage is a concrete one: f) implementation and construction. The author thereby expands the process of geodesign up to the actual execution, but using principles from the systemic approach, support from geoinformation technology, scenario modelling and decision-making processes based on feedback.

It is a method that relies on geospatial technology, and advances from the analytical stages to the prognostic, diagnostic and propositional stages of spatial planning, at different scales. In Brazil, many case studies have been developed with the application of Geodesign, in different scales and approaches (social, environmental, economic), especially at the Laboratory for Geoprocessing at Universidade Federal de Minas Gerais (Minas Gerais Federal University) (Zyngier et al., 2017; Monteiro et al., 2018; Casagrande and Moura, 2018; Palhares et al., 2018; Magalhães and Moura, 2020; Haddad et al., 2021; Moura and Freitas, 2021).

According to Moura and Freitas (2020), Geodesign work is supported using a Spatial Data Infrastructure (SDI) hosted on-line, in the form of a WebGIS, and tools that were optimized to facilitate the work stages involved, which vary according to the goals of each study. The authors suggest the use of GISColab platform. The platform was initially developed by GE21 Geotechnology (https://ge21gt.com.br/) and later adapted for Geodesign, as the product of Christian Freitas’ doctoral work, who programmed the software’s processes and optimized its functionalities, using the methodological proposals made by Prof. Ana Clara Moura.

The framework, which is open to variations, includes the following stages: a) Reading Enrichment (participants add notes and alerts regarding the characteristics, potentialities and vulnerabilities of the area, using their own prior knowledge or analysing the maps, to provide and “enrich” the available data; b) Building Ideas (sketches using points, lines or polygons, with titles and descriptions of the ideas they represent); c) Dialog Promotion (participants add comments to each and every proposal); d) Voting (using “likes” and “dislikes” to reach a final agreement). Cartographic representations using SDI can be complemented by other forms of representation that amplify geovisualization, as in the case of models built using drone-generated data. Organizers can employ dynamic tools to measure performance, such as charts depicting vote distribution, distribution of ideas per SDG, areas and their carbon sequestration index, tree per proposed area of recovery, among others (Moura and Freitas, 2021).

The framework developed by Moura and Freitas, which was employed in this work, addresses the challenges laid out by Miller (2012) for new research on Geodesign: 1) developing an understanding of Geodesign; b) developing a GIS technology that is centred on design; 3) Applying Geodesign in a variety of geospatial design issues; 4) Establishing Geodesign as a discipline, in terms of academic research and professional applications. The authors’ proposal is the result of over 40 workshop experiments in Geodesign, in different locations, scales and across different themes. Moreover, through the analysis of participants’ performance and their responses to questionnaires, in which they are asked to evaluate the process. This is accomplished using the technology that was initially developed by GE21 to structure an SDI (Spatial Data Infrastructure) platform, which allows the use of GIS data, and was further adapted by Moura and Freitas (2020) for the specific purposes of Geodesign. It has been applied in different case studies, which involved both academics and professionals from the planning industry.

This research uses their method and employs their platform, (GISColab), to include SDGs in co-creative and shared planning workshops, within the context of Geodesign.

1.2 SDGs – Sustainable Development Goals

According to the United Nations (UN) (2019), 55% of the world population in 2019 was living in cities, and the study’s forecast was that this number would reach around 70% by 2050. There is growing concern for the future of urbanized areas and those to improve their quality of life.

The United Nations Conference on Environment and Development (UNCED), held in Rio de Janeiro in 1992 and otherwise known as the “Earth Summit”, resulted in the approval of the Agenda 21, or The Rio Declaration on Environment and Development, which set out eight goals to promote sustainable development and justice among nations (UNCED, 1992). In 2012, the Rio+20 Conference reaffirmed the commitment to these goals and suggested a new agenda. In 2015, UN approved its “2030 Agenda for Sustainable Development”, aiming to achieve the end of poverty, the protection of the planet and guaranteeing global access to peace and prosperity. This agenda includes 17 goals for sustainable development.

The UN stresses that these 17 goals are integrated and indivisible, so that they can balance the three dimensions of sustainable development: economic, social, and environmental. (AGENDA 2030, 2015) (Figure 01). These are presented as global goals for a more balanced life in anthropogenic environments, with particular attention to cities. According to Andressa et al. (2020) urban planning can help achieve SDG goals as it can present instruments that address system inefficiencies and propose solutions for achieving more sustainable cities. The same principle applies to territorial and regional planning, when issues regarding conflicts of interest that affect anthropogenic environments need to be addressed.

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Figure 1. Representation of SDGs - Sustainable Development Goals. Source: UN, 2021.

However, to include SDGs in different scales of planning, they need to be decoded and presented to society. They need to be treated as a requisite in shared and co-creative planning, as in the case of Geodesign. Since the subject is still new to most people and is usually presented in rather vague, generic terms, it has not yet been concretely included in local projects and policies. It remains in the realm of intentions and abstractions, and it is necessary that we treat them in a way that allows people to understand and then, implement these goals in planning processes. With that in mind, this paper will report on experiments that aimed to bring awareness to SDGs in the context of regional planning, through Geodesign, to achieve “transformative learning” (Forester, 1999).

2. Development of the experiments

The first experiments that sought to include discussions regarding SDGs in Geodesign took place as the International Geodesign Collaboration (IGC) started providing incentive to these studies (https://www.igc-geodesign.org/). The group promotes annual studies, with a script that needs to be followed by the works that are submitted for presentation in the field of Geodesign. These scripts include sets of goals and methodological steps to allow for the comparison of results. One of the goals for the 2021 meeting was to include a stage where the designs, which should include SDGs, would be subject to evaluation.

2.1 Measuring SDGs in IGC studies

Participants had to create designs for their respective areas, using Geodesign scripts, for future scenarios in the years of 2035 and 2050. They had to adopt the approaches of non-adopter (which does not include innovations), late-adopter (initially do not include innovations for the 2035 scenario but include them for 2050) and early-adopter (already include innovations for the 2035 scenario). Coordinators were required to present the current scenario, which dates to 2020.

In 2021, 14 Brazilian universities took part in the study, producing 13 case studies on state capital’s metropolitan areas, where these universities are located, which included every Brazilian region. Aside from participating in IGC studies, the goal was to also conduct a comparative study of the Brazilian contributions to the research, thus evaluating the issue of scalability in the application of Geodesign in Brazil. This was done using GISColab, which, as mentioned earlier, is a Brazilian platform that addresses the shortcomings that were indicated by the participants of over 40 workshops.

During these workshops, participants were asked to apply Geodesign to collectively construct future designs for their areas, and each group had to propose 6 possible scenarios (according to the principles of non-adopter, late-adopter, or early-adopter for the years of 2020, 2035 and 2050). Coordinators would then build charts that evaluated each scenario, indicating whether the goals for sustainable development were accomplished. This was done using a table matrix, in which columns would be related to the study systems and the lines would relate to the SDGs. This was a requirement defined by the IGC.

Participants had to come up with ideas for the following systems, regarding the specific area they were planning for: Water Infrastructure, Agriculture, Green Infrastructure, Energy Infrastructure, Transport Infrastructure, Industry and Commerce, Institutional, Residence and Mixed Use, Tourism and Culture, and Carbon Credits. These systems form the columns of the analysis matrix, The lines correspond to the 17 goals of sustainable development: 1. No Poverty, 2. Zero Hunger, 3. Good Health and Well-being, 4. Quality Education, 5. Gender Equality, 6. Clean Water and Sanitation, 7. Affordable and Clean Energy, 8. Decent Work and Economic Growth, 9. Industry, Innovation, and Infrastructure, 10. Reduced Inequality, 11. Sustainable Cities and Communities, 12. Responsible Consumption and Production, 13. Climate Action, 14. Life Below Water, 15. Life on Land, 16. Peace and Justice Strong Institutions, 17. Partnerships to achieve the Goal.

Coordinators would be responsible for evaluating the proposals and filling out, in each cell of the matrix, with one of the following values: +3, +1, 0, -1, -3. They indicate: Most benefit, Benefit, Neutral, Detriment, Most Detriment (using the colours from deep purple to deep orange). The table would allow us to sum up the values per SDG and System, as well the general a total sum of the results, which would indicate the performance for each scenario according to the fulfilment of SDGs. Although this analysis was, in most cases, conducted by workshop coordinators by the end of the process, the group at Universidade Federal de Goiás opted for an evaluation alongside participants, who voted in every possible combination and produced an average result.

An analysis of the matrix results allows us to observe the presence of a significant degree of subjectivity in each judgment. For instance, it is up to coordinators to decide if an idea is related with one, or more, SDG. However, when comparing the resulting matrices, judgments range from the very rigid to the very positive. For instance, we can compare the matrices from Universidade Federal de Minas Gerais (UFMG) (which analysed the Belo Horizonte Metropolitan Area) and Universidade Federal Rural do Rio de Janeiro (UFRRJ) (which analysed the Rio de Janeiro Metropolitan Area), in which the sum totals were 92 and 239, respectively. (Figure 02).

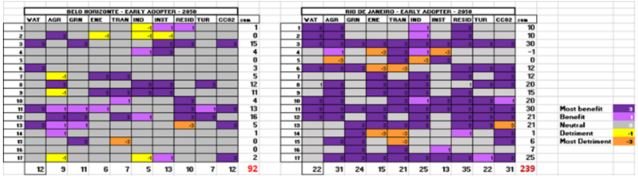

Figure 2. Evaluation matrices of SDGs created by UFMG (Belo Horizonte) and UFRRJ (Rio de Janeiro). Source: authors.

It is worth considering how much this subjectivity and differences in reference can impact the overall result of this experiment. This is associated with the problems regarding rankings, which are widely used to define areas with higher priority for investments and interventions. This would pose a significant problem if a comparative analysis was used to define the most vulnerable metropolitan areas, which in turn would receive more attention and resources. Nonetheless, in the context of an isolated workshop, the results simply indicate which SDG themes were positively contemplated or not.

The experiment led to the following observations: a) participants informed they wished they were informed about the goals before creating proposals; b) shared evaluations proved richer as a learning process than when evaluations were conducted only by coordinators; c) comparative analysis of the results of each workshop reveal a wide difference in values, which, in turn, points to significant differences in how judgments were made; d) there is little clarity and broad uncertainty regarding which actions and proposals indeed contributed to achieving SDGs; e) performances should not be evaluated in absolute terms, but rather in relative terms, comparing each of their performance curves; f) the only possible comparison would be general performance, if there is an increment between the 2020 and 2050 scenarios, or between non-adopter and early-adopter.

By placing values in a time chart, which, for instance, would evaluate the variation of the non-adopter - late-adopter - early-adopter approaches, it is possible to note an increment in every case study. There were improvements in SDG fulfilment in the last scenario. This can be observed in the chart that displays the values directly (Figure 03) or in the chart that normalizes the values, using a single initial and final value (Figure 04). In both charts the curves move upward, and analyses regarding the inclination of the line can be used to understand how increments took place.

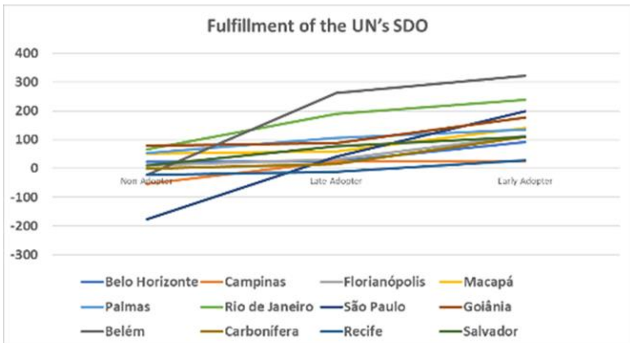

Figure 3. Comparative chart of SDG fulfilment across scenarios - realized values. Source: authors.

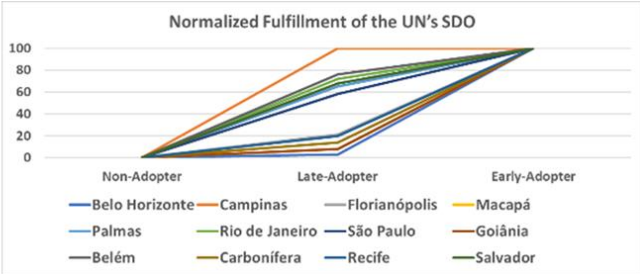

Figure 4. Comparative chart, SDG fulfilment across scenarios - values normalized with a single minimum and maximum value. Source: authors.

2.2 Proposing a dynamic measuring of SDGs as a support to decision-making

The analyses conducted in the 13 Brazilian studies submitted to IGC allowed us to see it was necessary to raise SDG awareness during workshops to achieve our research goals. The change in how the goals were presented would help participants gain more interest on the subject, while also working as a support to opinion building.

In our Geodesign workshops, we have been using a Brazilian platform for shared planning and co-creative processes: GISColab. GISColab was created to support planning processes based on Geodesign in a flexible way, in order adapt to different frameworks, according to the specific needs of the case study. The most widely tested process for using it starts with listening to citizens' opinions and reading enrichment, followed by the construction of their ideas. Participants start by analysing a collection of maps, organized in an SDI (Spatial Data Infrastructure), that presents the main variables, which they can combine freely, for them to choose the right place and idea according to their thinking (Moura and Freitas, 2021).

GISColab is a web-based platform based on the principles of Web-GIS (access to data collections through the Internet), SDI (spatial data infrastructure protocols, which can be accessed via WMS, WFS, WPS), as well as the parameters set by the Open Geospatial Consortium (OGC). Aside from allowing access to data, the platform allows for further data input, which work as a Volunteered Geographic Information resource, as well as script-based applications that can automate relevant processes within the workshops. GISColab is structured around three main components: a) a geographical base, using GIS; b) a Geoserver map server; c) a Metadata Catalog; d) a WebMap/WebGIS.

Using the initial code by GE21 Geotechnology, the platform was further developed to include layer generation processes and display dynamic information, as in the case of the dynamic layers with notes, dynamic area measurement indexes and carbon sequestration values (for use in proposals regarding carbon credits), dashboards that support decision-making, among others. These dynamic layers are the product of web processing services (WPS) and programmed to fulfil the specific goals of each workshop, thus making Geodesign processes much more flexible and adaptable.

To approach SDGs, a WPS-based script was created to compute the number of times each of 17 goals was mentioned in the ideas created by participants, in each scenario. Therefore, participants themselves had to inform which goal or goals their proposals would address. Therefore, participants are further informed on the relevance of SDGs, and starts to associate planning to the fulfilment of the global set of agreements. The chart, based on WPS, is dynamic and updated during the workshop. Usage of the dynamic chart of SDGs fulfilment during the workshop conducted for the Salvador Metropolitan Area, jointly conducted by the Universidade Federal de Minas Gerais and Universidade Federal da Bahia. (Figure 05)

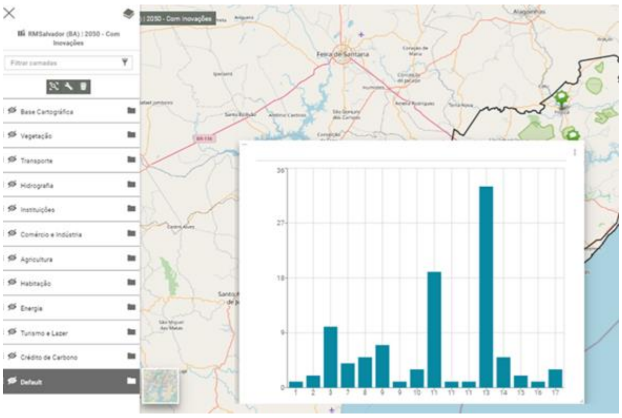

Figure 5. Histogram with the distribution of ideas according to SDGs. In the example, most proposals considered goal 13 (Climate Action), whereas other goals were either poorly or even not contemplated at al. Source: authors

These studies evolved into a second and more complex experiment, regarding the Iron Quadrangle region, in an environmental studies workshop, with emphasis on climatic issues and vegetation cover. Since the workshop was skewed towards environmental issues, the goals 11, 13 and 17 were presented to stimulate positive contributions on the subject. Nonetheless, when evaluating negative impacts, all the goals were taken into consideration. During the workshop, we noted participants worked with goals number 6, 8, 9, 11, 13 e 17. Namely 6 - Clean Water and Sanitation, 8 - Decent Work and Economic Growth, 9 - Industry, 11 - Sustainable Cities and Communities, 13 - Climate Action, 17 - Partnerships to achieve the Goal.

For goals 11, 13 and 17, coordinators promoted a discussion on what they meant and motivated participants to reflect on the subject, which most people seem to find rather vague. These goals were chosen according to the environmental approach of the study, but also due to the specific characteristics of the Iron Quadrangle. The Iron Quadrangle is an area rife with conflicts of interest, given its notable environmental value (water resources and valuable vegetation cover, namely the Mata Atlântica and Rupestrian Fields), but also its role as a source of iron ore and gold, which is at the core of the State's economy. Serious conflicts also include urban growth and the preservation of notable landscapes that relate to colonial history, not to mention the mountain ranges that form the essence (genius loci) of the state of Minas Gerais. (Figure 06). Thus, they approach environmental issues, but also consider economic and social impacts, which are linked to employment and sustainable cities.

Figure 6. The Iron Quadrangle and its landscape, including conflicts of interest. Source: authors.

During the workshop "Iron Quadrangle - An Environmental Approach and Sustainable Development Goals", participants went through the following stages: a) Reading Enrichment; b) Creation of Ideas; c) Dialogs; d) Voting. However, first, they were further informed of the key SDGs and, when creating their ideas, had to inform whether they were contributing (positively) to achieving one or some of them, as well as is if their ideas eventually involved a negative impact on these goals. The dynamic chart, presented as a histogram, showed the contemplated SDGs, highlighted the most contemplated ones, but also pointed out the negative impacts, thus improving workshop performance. (Figure 07).

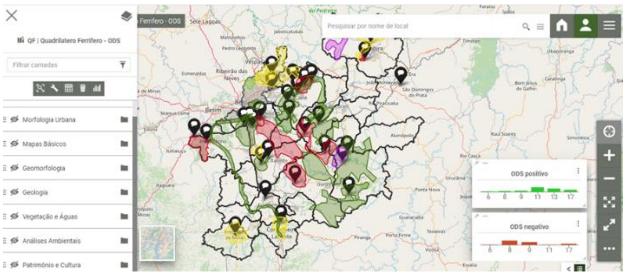

Figure 7. The workshop "Iron Quadrangle - An Environmental Approach and Sustainable Development Goals" in GISColab, with histograms that evaluate SDGs. Source: authors.

3. Analysis and Discussions

Initially, it is important to highlight the significant improvement on the quality of the proposals created by participants, in the form of ideas for the following themes: leisure, risks, landscape and climate. The data set was organized into the following systems: Geomorphology, Landscape Ecology, Vegetation and Urban Morphology. In other words, a collection of maps to support reading enrichment and idea construction. Ideas regarding landscape received the most interest, followed by risks, which suggests participants understood the essence of the Iron Quadrangle and its role as a notable landscape.

Goals 11 and 13, related to Sustainable Cities and Communities, and Climate Action, stood out from others when we analysed the association between participants' ideas and SDGs. Sustainable Cities and Communities received the most proposals, which demonstrates a commitment to social and economic issues, expressed through specific ways of perceiving the landscape. The least contemplated goal was item 6, Clean Water and Sanitation, probably due to the regional scale of our study, since these issues are mostly associated with an urban scale. It should be noted that all the goals were somehow contemplated, which indicates that participants fully understood the approach they were presented.

Regarding the negative impacts that may result from their proposals, goals 8, Decent and Economic Growth, and 9, Industry, were most affected. Given that the Iron Quadrangle is an area exploited for gold and iron ore extraction, acting as Brazil's the main source of iron ore and as Minas Gerais economic core, some modifications in priorities, allowing for greater concern for environmental and risk protections, results in a negative economic impact. Eventual limitations to and control of mining activities would result in losses in employment and industry, which demands further investigations into alternative economic activities. The SDGs with the highest negative impact are also the ones that received few positive proposals, which indicates the need to improve their discussion in future iterations. At last, it bears noting that participants considered their proposals had no negative impacts regarding objective 13, Climate Action, since their ideas were focused on the environment (Figure 08).

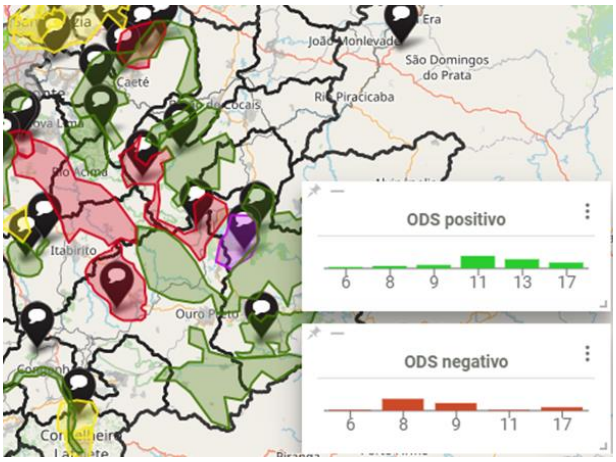

Figure 8. Histogram shows the distribution of ideas according to their positive or negative impact on SDGs. Source: authors.

4. Closing Remarks

Our comparative analysis of the case studies on 13 Brazilian metropolitan areas, developed by 14 Universities in contribution to the IGC, initially showed that: It was possible to observe a significant increase in SDG compliance intentions, from the 2020 scenario to the proposed 2035 and 2050 scenarios, indicating that the method and framework favoured the evolution of the ideas. However, it is necessary to highlight participants manifested their interest in receiving more information regarding SDGs before working on their ideas, since the initial measurement intended to show how freely constructed ideas would adhere to these global objectives. This was observed when coordinators conducted their post-workshop analyses and measurements, as well as when they conducted them alongside participants.

However, we believe it is not enough to simply inform that SDGs compliance would be measured after the workshop, given that there is little awareness of the subject and that they are still seen as being very abstract in nature. It would be necessary to inform participants of the goals, provide examples and promote a discussion on their importance before they started working on ideas. In other words, it was necessary to bring a generic concept into the realm of concrete, practical possibilities. For this informational stage to take place, and to stimulate participants' interest on the subject, a case study involving the Iron quadrangle was conducted, focused on environmental aspects. Since this was a thematic workshop aimed at a specific context (environmental), it was possible to select a given set of goals to be presented to participants, without restricting their ability to include other goals if they wished to (they included 6).

The result was the creation of far more qualified ideas, which were much more centred on real, current issues. The entire process, from reading enrichment to idea proposal, dialog building and voting, was very assertive in their understanding of local reality. According to the results from a questionnaire survey, most participants indicated an increment in their interest on the reality of the area (Iron Quadrangle), the method (Geodesign) and SDGs. The analysis of these results suggests the workshop provided a solid ground for opinion building and further qualified the overall experience by achieving a form of "transformative learning", as proposed by Forester (1999). This principle underscores the educational character of Geodesign, in which learning is the result from experience and increased interest on a given subject.

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