Geodesign Applied to Propositional Scenarios of Medium and Long-Term Sustainable Projects for Rio de Janeiro Metropolitan Region, Brazil

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Abstract. As the world has become more connected, the scale of cities would be no different. Thus, it became necessary to expand the solutions to meet the planning expectations related to the urban environment in response to contemporary challenges. At the same time, the advent of new information and communication technologies, combined with the popularization of mobile devices, created opportunities to increase the involvement of ordinary citizens in activities of geolocalized data generation and maintenance - Volunteered Geographic Information. Parallel to this scenario of collective data generation, Geodesign framework emerges to support decision making, based on the generation of critical awareness and the co-creation of ideas. In this context, this article reports the experience of a methodological experiment developed in the scope of the project "Geodesign Brazil: Trees for Metropolitan Regions" through the case study of Rio de Janeiro Metropolitan Region, in which workshops were held using the collaborative and digital platforms GISColab and Vicon SAGA. For four weeks a group of collaborators gathered into virtual meeting platforms to apply Geodesign methodological procedures, performed into the following steps: (1) analyzing and enriching the local knowledge base with geolocalized annotations; (2) propose projects considering non-adopter, early adopter, and late adopter scenarios for 2035 and 2050; (3) evaluate their impacts over the UN Sustainable Development Goals. The study showed that inclusive and democratic methodologies supported by platforms encourage discussion, and support decisions on the importance of conscious urban and environmental planning.

Keywords: Volunteered geographic information · Sustainable development goals · Urban planning · Collaborative design

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1 Geodesign and Volunteered Geographic Information in the Perception and Collaborative Construction of the Urban Space

As the world has become more connected, the scale of cities would be no different. Thus, it is necessary to expand expectations and develop processes that relate to the urban environment in response to contemporary challenges. Regarding the activity of urban planning, the active participation of all actors, whether users or specialists, has become essential. However, when it comes to collectivity, there are countless challenges inherent in the premise of mediating conflicts of interest. In this context, there is the proposal of Geodesign as a method to support decision making, based on the generation of critical awareness and the co-creation of ideas [1–6].

Geodesign proposes design models for and with the landscape, being the synthesis of a set of concepts and methods from the association of geosciences and design disciplines. The main objective of its application is the elaboration of collective agreements for the modification of the territory through co-creative projects and plans [1, 2, 6, 7]. The method improves traditional planning activities based on the potential of Geographic Information Systems (GIS) and geovisualization, which become a common language among those involved. Through shared codes, it is possible to collect ideas collectively for the territory, based on impact analysis and simulations on demand. Thus, Geodesign integrates scientific knowledge and social values into the design of alternative futures [5, 6].

In the last decade, the Geodesign method has gained evidence, having been applied at different scales - e.g., towns [8], water courses [9], and neighborhoods [10]; for different purposes - e.g. multidisciplinary planning [11], landscape and wildlife management [12], and propositions for climate action [13, 14]; and localities - e.g. Asia [15, 16], Europe [17, 18], Africa [19, 20], and Americas [21, 22]. This diverse applicability reiterates the potential and versatility of the methodological mark.

Considering the current world scenario of social isolation, it is important to mention that geodesign workshops can occur both in person and virtually. Other than that, the methodology can be conducted analogically and digitally. In the digital scenario there are online platforms, such as Geodesign Hub®[1] and GISColab[2] [23], that allow groups to work presential or remotely, with no limit on the number of participants involved, through a server that stores data, and organizers that conduct the co-creation or codesign dynamics.

In parallel, the advent of new information and communication technologies, combined with the popularization of mobile devices, create opportunities for increasing the generation of contextual information, originated from social participation, especially when individuals face problems and see opportunities in their own communities. Portable equipment, smartphones equipped with multimedia resources (photos, videos, audios) and GPS receivers, wireless networks and smart objects expand the limits of places and moments in which an individual can collaborate, as they allow the use of data

[1] Geodesign Hub® - https://www.geodesignhub.com.
[2] GISColab - http://www.giscolab.com/geodesign.

from their location and make environments increasingly interactive, changing their relationship with the urban space and opening space for the offer of innovative collaborative services [24].

In this context, the involvement of ordinary citizens in activities of generation and maintenance of geolocalized data - Volunteered Geographic Information (VGI), has become a common fact, intensely fostered, not only by non-profit initiatives, such as OpenStreetMap®, but also by the giant digital platforms, such as Google®.

In this scenario, this article reports on the experience of a methodological approach developed within the scope of the project "Geodesign Brazil: Trees for Metropolitan Regions" - a network of collaborators from all regions of the country that aims to discuss and propose ideas for their respective locations using Geodesign, in the realization of workshops and using the Brazilian platform GISColab, among other resources and specificities of each region. In the case study reported, specifically, the collaborative platform Vicon SAGA was also used.

2 The Dynamics of the Workshop in the Light of Geodesign: Processes and Procedures

In addition to the countless and increasingly simplified possibilities for building knowledge databases and voluntary participation, supported by Geodesign, a group of 10 researchers met virtually to develop a simulated model of sustainable territorial planning for the Rio de Janeiro Metropolitan Region (RJMR). It is important to point out that the majority of the group did not inhabit in the region.

The project proposals developed at the workshop were developed in two-time scenarios (i) 2035 and (ii) 2050, medium and long term, respectively; and in three variations of propositional positioning for each time scenario, being (i) non adopter; (ii) late adopter; (iii) early adopter; following the framework suggested by IGC [25].

In addition, the dynamics of the workshop developed in four meetings (Fig. 1), and in (i) the first meeting, reading enrichment was carried out; in the (ii) second moment, the non-adopter proposals for 2035 (Group A) and non-adopter proposals for 2050 (Group B) were prepared, both observing the information constructed in the reading enrichment; at (iii) the third meeting, late adopter proposals for 2035 were prepared, observing reading enrichment (Group A) and late adopter proposals for 2050, observing non-adopter proposals for 2035 (Group B); and in the last meeting (vi) the proposals for 2050 early adopter were collectively elaborated and negotiated, observing the late adopter proposals for 2035 (Group A and B), in order to also meet all the systems and variants put up for discussion in relation to the objectives of the agenda Sustainable Development Goals (SDG), established by the United Nations General Assembly in 2014 [26].

For the purposes of applying the Geodesign methodology, a fundamental factor is the need to provide a fully interactive, integrating environment, which enables the process of joint discussions and decisions, that is, collaboratively, and in the current context also remotely. Thus, meeting the methodological requirements, and operating in a free and objective manner, the web platforms Vicon SAGA[3] and GISColab were adopted jointly

[3] Vicon SAGA - https://viconsaga.com.br/.

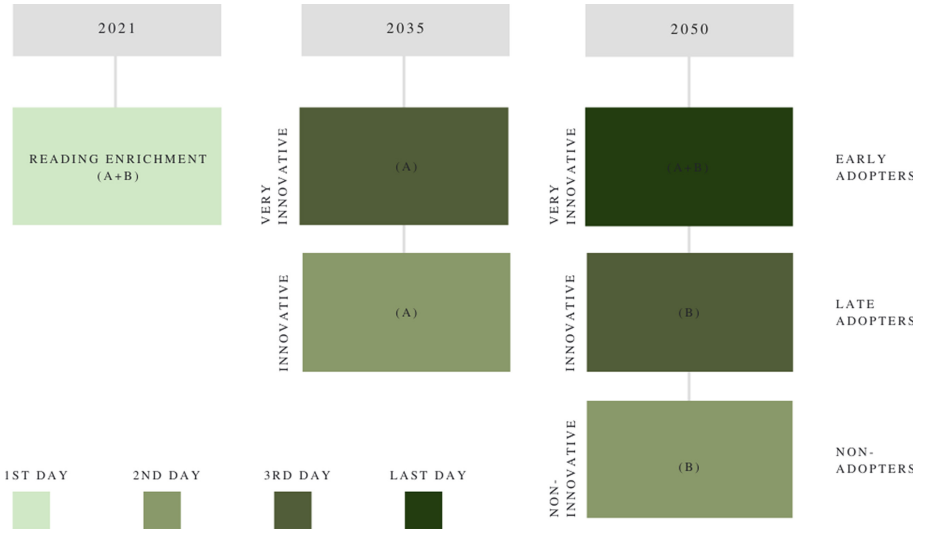

Fig. 1. Methodological development of the workshop in steps. Source: The authors.

by the work team, to support and register the products of the activities, annotations, and project proposals, respectively, as detailed below.

The study area in the reported experience, Rio de Janeiro Metropolitan Region (RJMR), also known as Grande Rio (Fig. 2), is home to approximately 13 million inhabitants [27], being the second largest metropolitan area in Brazil (after São Paulo), the third in South America and the 16th largest in the world in 2020.

In this context, considering its geographical position and due to historical, economic, legal, and political processes, the RJMR is currently considered the second pole of demographic concentration and economic activities in the country, containing a large volume of activities and flows, supply of more specialized assets and services, and a high rate of urbanization. In the state, the RJMR concentrates, on average, 90% of the state population and is overburdened regionally by the concentration of most services, reducing the political and economic strength of the interior of Rio de Janeiro [28].

Step 1: Reading Enrichment

The first methodological step consists of interpreting the collection of thematic cartographic databases in the study area, based on the overlap of the thematic classes of each of the maps raised, considering: (i) physical factors, such as terrain topography, geomorphology, soils; (ii) biotic, such as expressive vegetable mass and NDVI; and (iii) anthropic, such as transport, housing, industries, commerce, and education. The data collection was extracted from Brazilian institutional bases, satellite image, and OpenStreetMap® and processed by Geoprocessing Laboratory[4] staff.

From the combined interpretation of these data layers, the systems can provide, in a holistic way, intrinsic and relational information about distances, proximity, access, age,

[4] The Geoprocessing Lab (Geoproea) - https://geoproea.arq.ufmg.br/laboratorio.

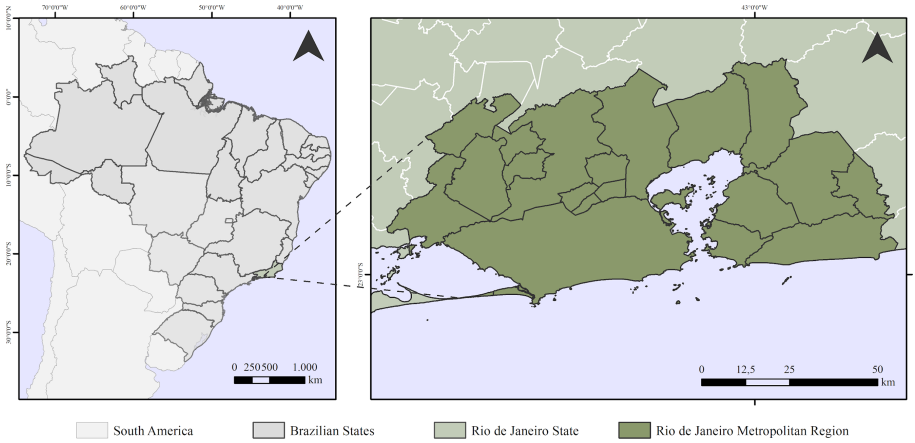

Fig. 2. Study area: Rio de Janeiro Metropolitan Region, Brazil. WGS84. Source: The authors.

dependence, similarities and other characteristics of the environment [29]. Therefore, the wide and diversified thematic cartographic collection made available to the work team helps them to understand the local geodiversity, in addition to pointing out, by the combination of independent factors, areas with potentials or demands (risks).

Each contributor of the workshop had access to the Web SIG Vicon SAGA, where he or she could perform, in an agile and direct way, the geolocalized annotation of his observations regarding demands and potentials relevant to the enrichment of the current knowledge base of RJMR. At the end of the stage, 87 notes were added to the knowledge base (Fig. 3), categorized according to the following themes: agriculture (1%), trade and industry (8%), energy (9%), housing (16%), hydrography (14%), institutions (5%), transport (18%), tourism and culture (23%), and vegetation (6%).

Step 2: Elaboration of Non-adopter and Late Adopter Scenarios

In the stage of preparing non-adopter proposals for the years 2035 and 2050, the work team sought to add the demands registered based on reading enrichment, added to the examples of successful projects previously practiced by managers public services in the country. Many proposals were motivated by the main challenges and chronic problems faced by the citizens residing in RJMR (e.g., supply of energy, water, and urban mobility).

Among the project proposals prepared by the group, the following stand out: (i) industrial pollution control mechanisms; (ii) creation of ecological corridors with the objective of connecting the fragments and reducing the impact of heat islands; (iii) encouraging and making urban expansion compatible with the promotion of tourism, leisure, and culture; (iv) light rail; and (v) creation of a green belt for the preservation of Baía de Guanabara.

In the late adopter scenarios for the years 2035 and 2050, it is possible to observe a certain difficulty in preparing proposals, especially to meet the goals established for carbon credit (an increase of 30% by 2050). However, the results were satisfactory and among the proposals, the following stand out: (i) restoration of riparian ecosystems; (ii) use of navigable maritime strips for public transport; (iii) creation of optimized

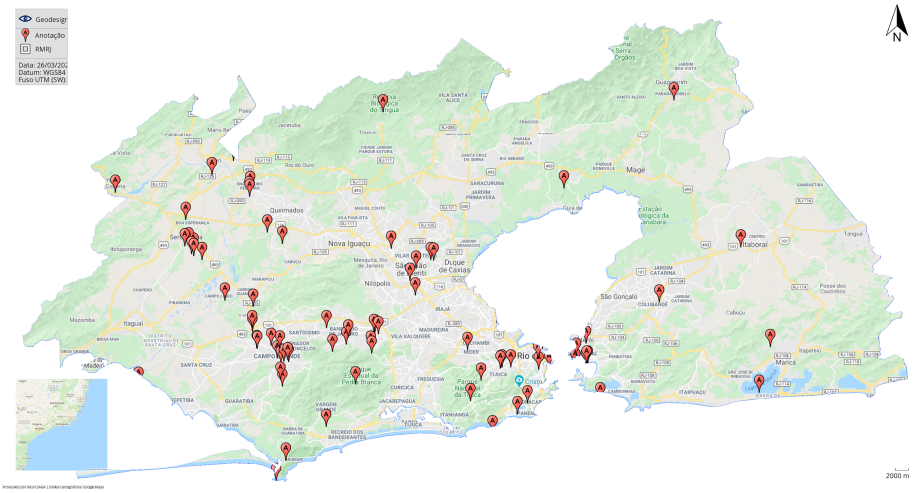

Fig. 3. Reading Enrichment: Map of Rio de Janeiro Metropolitan Region with notes from contributors regarding demands and potentials relevant to the enrichment of the current knowledge base. Source: Vicon SAGA Platform - RJMR Geodesing Project (link).

and shared workspaces; (iv) sea wave energy; and (v) conservation and expansion of expressive vegetation cover. All designs are indicated at Fig. 4, below.

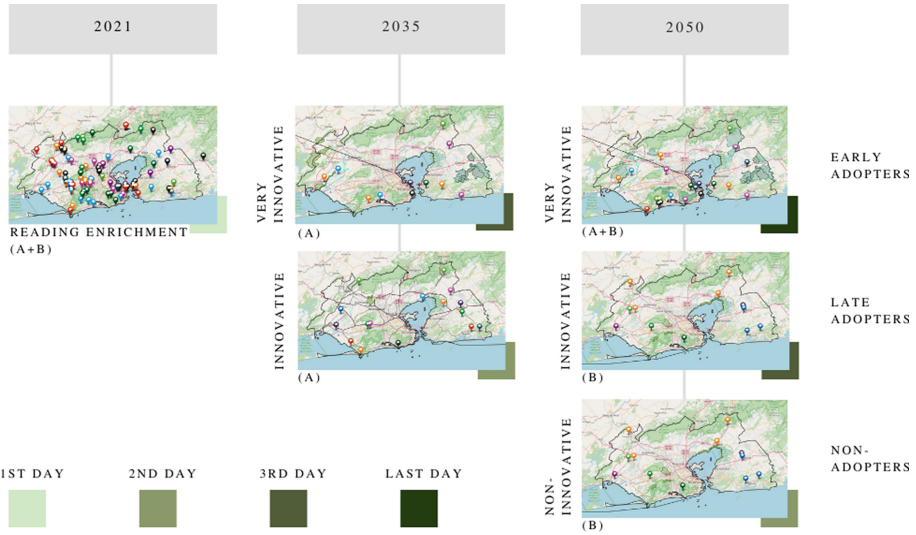

Fig. 4. Resulting medium and long-term scenarios for RJMR. Source: The authors.

Step 3: Elaboration of the Early Adopter Scenario

Finally, in the early adopter positioning, for the year 2050, the increase in participation was quite considerable in quantity and quality of the proposals, it is believed that due to the familiarity established systematically with the methodology. In this way, it is worth highlighting some interesting proposals: (i) seawater desalination complexes for the purpose of supplying this resource to the population; (ii) monitoring panel of individualized health of the population; (iii) high-speed train; (iv) sustainable community complexes; and (v) conservation, creation, and expansion of expressive vegetation cover. This stage was also marked by negotiation and mediation, using resources available on the GISColab platform, carried out to reach a common consensus on the final proposal.

3 Results and Discussion: Analysis of the Impacts of Proposed Projects Against the Sustainable Development Goals (SDGs)

After completing the proposed steps, carried out through group discussions, over the 4 meetings in Google Meet virtual rooms, the final step consists of analyzing the impact of the suggested projects within the 3 innovation scenarios for the year 2050 on the 17 objectives of the sustainable development agenda (SDGs), established by the United Nations General Assembly in 2014 [26]. The SDGs cover social and economic development issues, from poverty eradication, actions against global climate change, even the development of sustainable cities and communities.

Figure 5 presents the matrix of correlation and weighting of the impacts caused by the project proposals for the scenarios non-adopter (a), late adopter (b) and early adopter (c) for the year 2050 in relation to the SDG proposed by the UN.

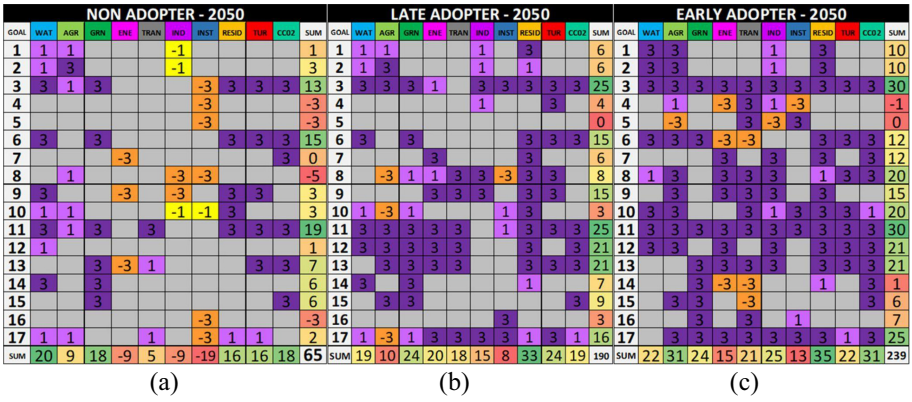

Fig. 5. Correlation matrix and weighting of the impacts caused by the project proposals for 2050 on the 17 Sustainable Development Goals proposed by the United Nations [26]. Source: Authors.

From the analysis of the impact matrices, it was found that the positive impact caused by the proposed projects on the sustainable development goals was enhanced as the innovation scenarios intensified. In other words, they were more daring.

In addition, the sums available at the ends of the matrices made it possible to verify in a direct and quantifiable way which systems (columns) were more or less contemplated. Similarly, the sum represented at the right end of the matrix, made it possible to verify the intensity of compliance with the sustainability goals (lines). For example, for the non-adopter scenario (Fig. 5a), it appears that the Water system (WAT) was the most contemplated by the proposed projects. On the other hand, in this same scenario, the Institutional system (INST), in addition to not having been favored, was severely damaged (negative sum equal to –19), given the impacts caused by the proposed projects. Under the aspect of sustainable objectives, while the goal "11 - Sustainable Cities and Communities" was the most privileged by the proposals, the goal "8 - Decent work and economic growth" was the most affected by the actions proposed in this scenario.

In this way, evaluative instruments, such as the impact matrix presented, act as a fundamental analytical resource for the process of prognosis of sustainable evolution. Therefore, it is essential that the methodology considers and enables the construction and analysis of these quantitative models. In a systematic way (in rounds, for example), it is possible to foster reflections and discussions among the community involved about the impacts (positive and negative) of the proposed projects. Thus, the group will be able to reflect and even reconsider on the feasibility of certain proposals that may negatively enhance sustainable objectives, operating as feedback mechanisms for the support system for territorial planning.

4 Conclusions

This experience showed the relevance of social relations in the territory and converge to the concept of cartography of social action presented by Ribeiro and Silva [30], who argue that "cartography must value social experience, really tracing the transformation of territory into used territory, territory practiced, and experienced territory", also pointing out that the territory should not be a category of analysis when it is disassociated from the relations that coexist there.

The importance of extracting geolocalized information lies in its various possible applications, whether public or private, in various areas of knowledge. In the case of urban planning, the growing need for knowledge and monitoring of the geographical space finds in Remote Sensing tools that allow obtaining information necessary for effective environmental management.

The practice taken corroborates with the results achieved on the activity reported by Scorza (31), in which the workshop participants showed adherence to the taxonomy and gave positive feedback regarding the proposed method. Furthermore, since most of the group does not live in the region, it is important to emphasize that the dynamic, especially the Reading Enrichment step, fulfilled the function of addressing the characteristics of the place. The use of the map layers, as well as the appointments made by the inhabitant participants – here supported by Vicon SAGA, were widely considered in the proposition phases. These findings reiterate the acceptability of the Geodesign method and highlights the improvements proposed by the Brazilian platform.

The dynamics of the workshop, as well as its processes and procedures, allowed realize the potential to be explored regarding use of digital and online tools in collaborative planning of the cities, especially in the current context of the global pandemic.

In this sense, although at first it seems like a weakness, working with a group of people in the workshop who did not belong or knew the study area, makes the reading enrichment step quite important for the exploration of georeferenced data, and as a consequence, to the formation of knowledge and critical thinking about the territory.

As for the analysis of compliance with the SDGs, although the matrices show optimistic scenarios, there is a gap in the literature to be worked on regarding the establishment of less subjective metrics to assess compliance and performance, and in this sense, a potential development of future studies.

Finally, inclusive and democratic methodologies, such as Geodesign, supported by collaborative and digital platforms, such as GISColab and Vicon SAGA adopted in the study (among many others existing in the field of VGIs), showed and supported the discussion of the importance of urban and environmental planning conscious for the guarantee of environmental resources in the medium and long term.

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