The Potential of Geodesign for the Optimization of Land Use in the Perspective of Sustainability: Case Study of the Metropolitan Region of Campinas

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Abstract. The main objective of this article is to present and discuss the experience of a Geodesign workshop aimed at the Metropolitan Region of Campinas, SP. It was intended to debate the potential of the Geodesign method to reflect on the characteristics of the territory and propose alternatives for the proper use and occupation of land in the region from the perspective of sustainability. The workshop offered support for the participants to co-create alternatives for the sustainable planning of the territory and to develop the potential of the area. Its main characteristic was the elaboration of proposals based on the sustainability triad: Environmental, Economic and Social. The results showed that the methodology favors the preparation of proposals for adequate land use, allowing for an evolutionary process of co-creation of ideas, as the activities were developed in an evolutionary way, that is, the proposals were created for the 2035 and 2050 scenarios, no innovations, few innovations and many innovations. After the preparation and presentation of the proposals, the groups analyzed them for the 2050 scenario, showing that this step is essential for the critical analysis of the ideas, allowing to verify which systems were fully contemplated, which were moderately covered and which were not adequately covered. Thus, it is suggested that the evaluation stage precedes the adequacy and finalization of the proposals.

Keywords: Geodesign · Metropolitan regions · Territorial planning · Co-creation

1 Introduction

In Brazil, the urbanization process intensified from the 1960s onwards, generating a rural exodus, that is, the population leaving the countryside for urban areas. Most of the population started to live in cities, generating its rapid growth. Based on data from

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the National Household Sample Survey (PNAD) [1], 84.72% of the Brazilian population lives in urban areas, and 15.28% in rural areas. This intense urbanization process triggered the phenomenon of metropolization, that is, cities grew beyond their limits, forming large metropolitan centers. The country comprises 74 metropolitan regions, which constitute complex territories, demanding effective planning methodologies.

This article presents the experience of the Geodesign workshop aimed at the collective development of proposals for the Metropolitan Region of Campinas (São Paulo, Brazil), in March 2021, with students from the "Urban Environmental Quality Analysis: support of geotechnologies for integration of thematic data", given by Professor Andréia Medinilha Pancher at UNESP. Two students from the postgraduate program in Geosciences at UNICAMP also participated.

This experiment was part of a group of workshops in 12 of the 74 metropolitan regions of the country, coordinated by professor Ana Clara Moura, from UFMG, all using the geodesign method and the Brazilian geodesign platform GISCoLab, created with the support of CNPq (project 401066/2016–9 and FAPEMIG PPM-00368–18) [2]. Each Metropolitan Region had its local coordination – in this case, Professor Andréia Pancher, from UNESP. In each case, certain aspects and approaches related to specific territories and stakeholder groups were emphasized. In the case of Campinas, it was decided to use the tripod of sustainability as a base, guiding the practice based on the potential contributions of the proposals to social, environmental and economic issues.

Geodesign was adopted as a methodology, an alternative for the collective solution of conflicts that settle in the territory. According to Steinitz [3], this method is based on and covers a set of questions and methods necessary to solve complex design problems, in varied geographical scales, ranging from a neighborhood to a city, a landscape or a watershed.

Geodesign is adequate for the exercise on screen, since it is based on the knowledge of the characteristics of a territory for the elaboration of proposals compatible with not only economic, but also social and environmental development. In this way, the method makes it possible to conduct collaborative practices that favor the broad participation of actors involved in the territory, including from researchers, planners, to the community that lives in the areas of interest.

2 Methodology

The workshop presented in this paper adopted geodesign as a method, a concept created by a group of researchers from the Harvard Computer Graphics Lab, from the beginning of the 21st century [4].

It starts from the principle of associating GIS systems with spatial analysis techniques, based on the production of visualizations, simulations and models of physical-territorial reality. In other words, the geographic dimension, geo, is allied to the purposeful nature of design practices [5]. In general, cartographic bases with different information about the territory to receive interventions are used, organized in superimposed layers, as a background for the collective exercise of deliberation on territorial transformations – co-design or co-creation.

In order to explain geodesign, Goodchild [5] emphasizes the distinction between Design with a capital "D" and a lower "d". The design with a lowercase "d" would be a

simplistic or even naive approach, anchored in the search for an "optimal solution" based on the combination of the initial objectives with the existing variables and restrictions. It would almost be an automation of the decision-making process based exclusively on technical parameters, enabling one to always arrive at a single result.

Design with a capital "D", on the other hand, would be the set of practices that take into account the conflicts between the actors involved in decision making, their biases, and the dialogue necessary to achieve a result - which may not always be the more appropriate based on technical parameters, but that reflects the possible consensus within a given group and its interests. In this sense, the GIS technological framework is used to support and improve the negotiation processes and the political nature inherent to territorial planning, and not to eliminate them, as is the objective of proposals such as SDSS (Spatial Decision Support Systems). For this, it is necessary to repeatedly return to the beginning of each stage of representation and design (feedback loops, or iterations), enabling the verification of the proposed decisions [5].

Based on these assumptions, Steinitz [3] proposes a framework for geodesign: a methodological framework in which six questions must be asked (explicitly or implicitly) by the working group, at least three times, constituting iterations that feedback and generate different models of the territory until the negotiation of a final proposal (Fig. 1).

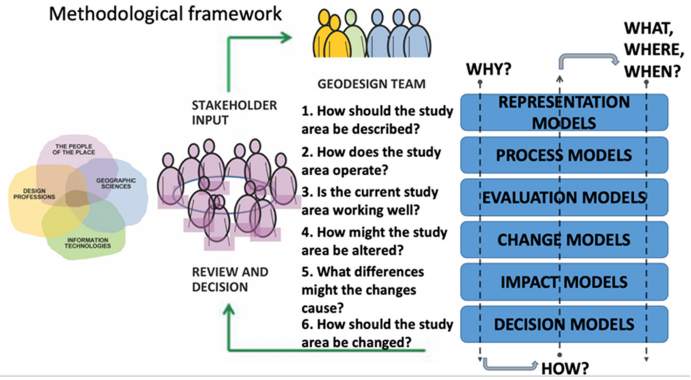

Fig. 1. Geodesign framework proposed by Steinitz [3].

Throughout this process, six models are generated – representation, process, evaluation, change, impact and decision – through which the process must move in search of a final collective agreement. In the following topics, it will be presented how these models were approached in the workshop in question, as well as the necessary adaptations to adapt the methodological framework to the analyzed context. The summary of the methodological steps of this work is shown in Fig. 2.

The main tool used to support the process was the GISCoLab platform [2]. GISCoLab was developed in partnership with GEOPROEA researchers, between 2015 and 2018, based on a series of case studies on Geodesign and co-creation of ideas for the territory. The analysis of the results of these experiences led the group to propose the development of a Brazilian platform, seeking to circumvent identified critical aspects, such as the risk

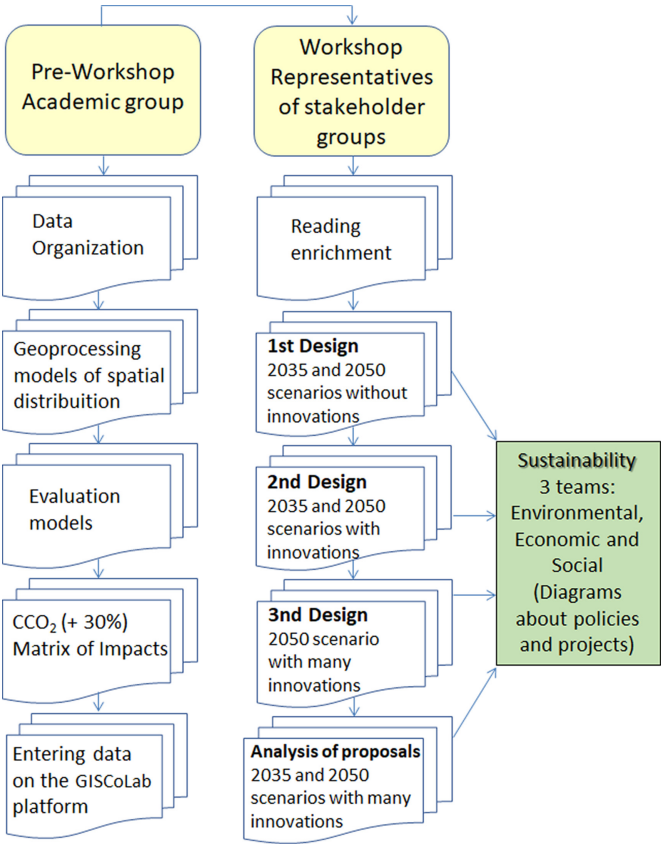

Fig. 2. Main steps in methodological framework. Source: The authors.

of inducing consensus or the low openness to participation in the initial stages of the processes.

Next, the characterization of the study area and the construction of working models for the MRC workshop will be addressed.

2.1 Area Characterization

The area of analysis was the metropolitan region of Campinas (MRC), created in 2000 through Complementary Law nº 870, of 19/06/2000. According to an estimate by the Brazilian Institute of Geography and Statistics (IBGE) [6], the MRC is formed by 20 municipalities, housing 3,304,338 inhabitants, with 2,725,293 people living in urban areas and only 71,844 in rural areas. The total land area is 3,644.9km^2, therefore, the demographic density is 767.40 inhab./km^2. (Table 1).

According to the data in Table 1, it is evident that the MRC is densely occupied, especially the urban area. It is a dynamic region, both economically and technologically, encompassing important research and teaching centers. The intense development of this

Table 1. Municipalities in the Metropolitan Region of Campinas/SP. Source: IBGE [6, 7].

Municipalities	Population (2010)	Estimated Pop. (2020)	Area (km^2)	Dem. Density (inhab./km^2)
Americana	210.638	242.018	133,91	1.807,29
Artur Nogueira	44.177	55.340	178,03	310,85
Campinas	1.080.113	1.213.792	794,57	1.527,61
Cosmópolis	58.827	73.474	154,66	475,05
Eng. Coelho	15.721	21.249	109,94	193,28
Holambra	11.299	15.272	65,58	232,89
Hortolândia	192.692	234.259	62,42	3.752,95
Indaiatuba	201.619	256.223	311,545	822,43
Itatiba	101.471	122.581	322,28	380,36
Jaguariúna	44.311	58.722	141,39	415,32
Monte Mor	48.949	60.754	240,57	252,54
Morungaba	11.769	13.781	146,75	93,91
Nova Odessa	51.242	60.956	73,79	826,07
Paulínia	82.146	112.003	138,78	807,05
Pedreira	41.558	48.463	108,82	445,35
Sta Bárbara D'Oeste	180.009	194.390	271,030	717,23
Sto Antonio de Posse	20.650	23.529	154,133	152,66
Sumaré	241.311	286.211	153,46	1.865,05
Valinhos	106.793	131.210	148,54	883,33
Vinhedo	63.611	80.111	81,60	981,75
Total	**2.808.906**	**3.304.338**	**3.792**	**871,40**

region caused the rapid occupation of the territory, without adequate planning. As a result, serious damage to natural resources was unleashed in this territory, demanding more effective land use and occupation strategies. The study area can be better understood in Fig. 3.

2.2 Preparatory Stage of the Workshop

To carry out a particular spatial analysis, with a view to proposing changes for the proper use and occupation of land, it is necessary to know the characteristics of the territory considered. Therefore, it is necessary to establish the analysis of thematic data of the study area, which was selected based on the most relevant themes to meet the expectations of the discussion.

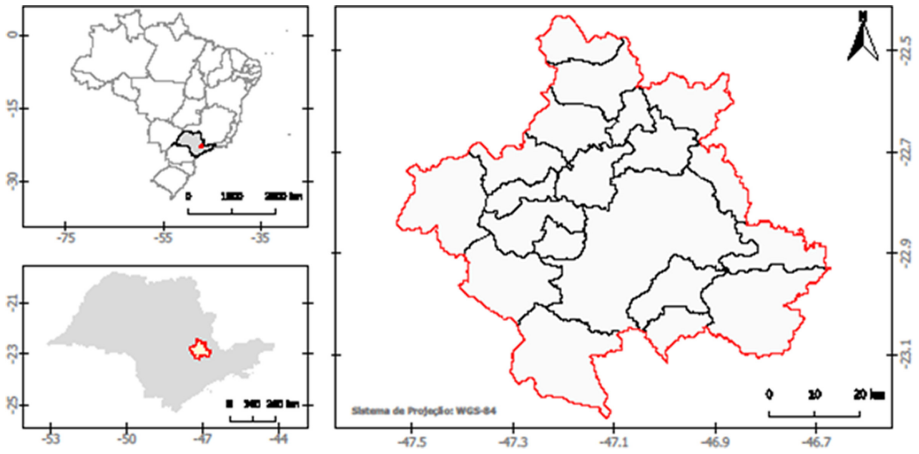

Fig. 3. Study area - metropolitan region of campinas (MRC). Source: The authors.

Thus, in the first preparatory stage, the academic group from the Federal University of Minas Gerais developed the Representation Models, comprising 43 layers of cartographic and thematic data of the main characteristics of the study area, obtained from various official databases. For this stage, 15 days of work were required in the geoprocessing laboratory LABGEO/UFMG. Then, the information layers were inserted into the GISCoLab platform. This platform was created by Christian Resende Freitas and Ana Clara Mourão Moura (UFMG); it is characterized by being dynamic and interactive, allowing the stages of the workshop to be organized in contexts.

In the second stage, the data layers were transformed into Process Models, allowing to analyze the spatial distribution of occurrences and phenomena, as well as the influence of each variable on the RMC, showing the functioning of the study area. Using geoprocessing methods, hypsometry and slope models were generated; of land use and land cover, through the digital classification of orbital images; of the vegetation quality index, by calculating the NDVI (Normalized Difference Vegetation Index); water supply, sanitary sewage, health and school service buffers, accessibility and capillarity of the transport network, concentration of commerce and services, in addition to the percentage of distribution of young people, average income estimate, population density, relative information to agriculture, energy (insolation, surface temperature), tourism and leisure, and carbon credit (core area metrics, by form factor and connectivity). These layers of geographic information served as the basis for the group's work.

3 Development and Analysis

After the previous elaboration of the cartographic and thematic data, the representation, process and impact models were organized, as well as the workshop, which are detailed in the following items.

3.1 Representation Models

The natural and anthropogenic physical characteristics of the metropolitan region of Campinas served as the basis for the establishment of 10 systems: Water, Agriculture, Green Infrastructure, Energy Infrastructure, Transport Infrastructure, Trade/Industry, Institutions, Housing, Carbon Credit, in addition to a system of free choice, which in the case of this study was selected as the Tourism/Culture/Leisure System. The objectives of the systems were:

a) Green Infrastructure - where to propose the conservation areas, implementation or expansion of vegetation, in order to minimize the effects of heat in densely built areas, restore the Permanent Preservation Areas, improve the conditions of protected areas, minimize the events of flooding and flooding and erosive processes, from the analysis of the existing vegetation distribution in the form of biomes, conservation units, vegetation quality index.
b) Hydrography – which springs and water courses require proposals for the recovery of the green, for the protection of water sources and ecological potential.
c) Housing - selection of the most suitable areas for the implementation of new housing, considering the most appropriate characteristics of the relief (hypsometry and slope), taking into account the urban expansion area, as well as the legislation regarding APPs and conservation units.
d) Transport – which sectors require improvements or expansion of road, rail and urban transport routes, considering accessibility and capillarity.
e) Institutions – in which areas there is a demand for health services, schools, taking into account the characteristics of the population (% of children, young people and the elderly) and the areas of influence of these services.
f) Trade/Industry – which areas can be expanded and which are suitable for expanding commerce and industry, based on information on average income and population density.
g) Agriculture – which areas are suitable for agricultural activity or for expanding existing ones, based on information on land use and occupation, altimetry, soils, insolation, road infrastructure.
h) Energy – which sectors are potential for the installation of new energy generators, considering the production of sustainable energy, such as solar (analyzing the conditions of insolation and surface temperature).
i) Carbon Credit – propose the conservation, expansion or creation of vegetation, with a view to increasing the carbon credit, considering the surface temperature, the characteristics of the existing vegetation (core area, shape, connectivity,).
j) Tourism/Culture and Leisure – identify favorable areas, using favorable aspects, such as archaeological sites, caves, museums, technology centers, theaters, cinemas, for exploration or increased visitation activities.

Below, some images of the representation model are shown, covering the Environmental axis: Land Use and Coverage and Conservation Units; Social: Practiced Urban Patch and Health and Education Equipment; and, Economic: Transport (Highways, Railways and Urban Roads) and Income, which deal with some characteristics of the MRC.

The elaboration of the models was based on satellite images (Sentinel 2A, from the Copernicus Program), through classification according to Land Use; as well as data provided by the public administration (urban stain, health and education equipment, income, administrative limits and Conservation Units for sustainable use and permanent protection) (Fig. 4).

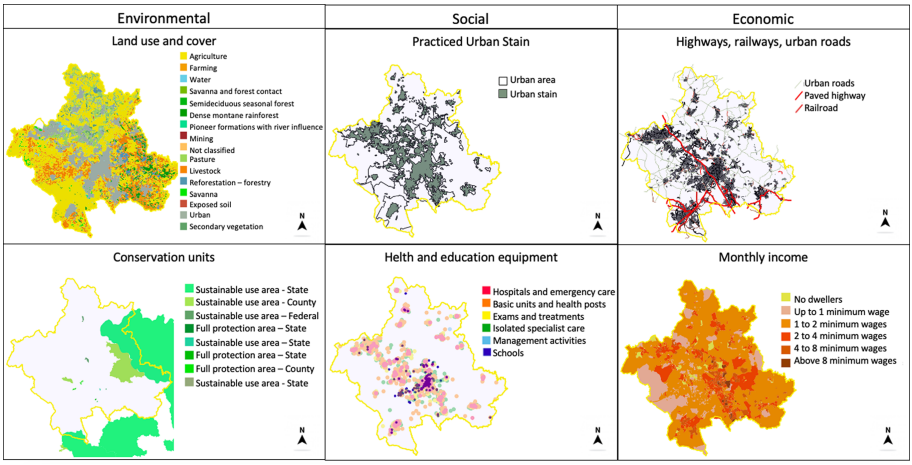

Fig. 4. Some thematic cartographic data produced, considering the sustainability triad. Source: LABGEO/UFMG.

3.2 Processes Models

The process models allow us to understand the functioning of the area, through the classification of the data elaborated, based on the interest of each System. In this model, there is a combination of data and the production of new information by the participants, presenting an analytical dimension.

Thus, the collection of thematic data from the RMC was distributed among the 10 systems. For each System, thematic maps were processed based on specific sustainability demands. From this collection, the maps referring to the Carbon Credit System stand out, involving the calculation of the surface temperature (from the mildest to the highest); the estimate of the most expressive vegetation; core area metrics, ranging from bad (no core area) to good (best core area dimension); metrics by form factor (perimeter/area), from bad (greater complexity) to good (less complexity); connectivity metrics (low to high); plus a summary of metrics (from bad to good). The processing of these data allowed the generation of representative maps of areas with conserved vegetation, areas that deserve attention in terms of restoration actions, and areas lacking green (Fig. 5).

3.3 Impact Models

The evaluation of the impact of the proposals was carried out predominantly in a qualitative way and consisted of a judgment. In the case of this study, this step was carried out in

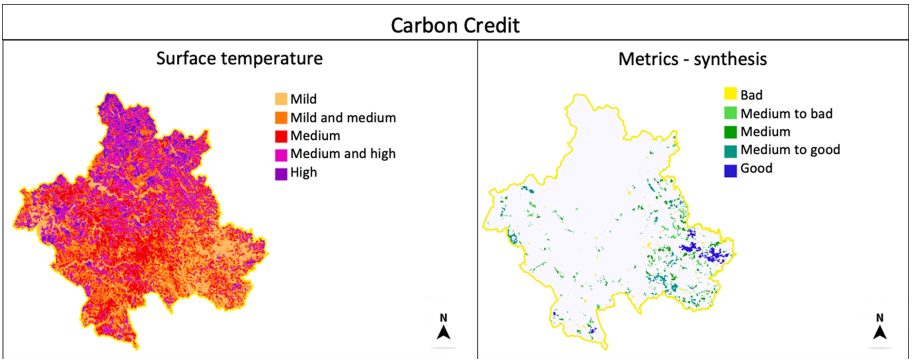

Fig. 5. Carbon Credit Maps: surface temperature and metrics - vegetation synthesis (core, shape and connectivity). Source: LABGEO/UFMG.

the last meeting (5th), based on a conflict matrix containing the 10 systems, which were evaluated considering the 17 objectives of the Objective of development sustainability (ODS) (Fig. 6), attributing the notes "Most Benefit", "Benefit", "Neutral", "Detriment" and "Most Detriment", each one related to a color in a hierarchical order (Fig. 7).

	EARLY ADOPTER - MUITAS INOVAÇÕES - 2050										
	AGUA	AGRIC	VEGET	ENERG	TRANS	COMIN	INSTI	HABIT	TURC	CC02	SOMA
Sustainable Development Goals	WAT	AGR	GRN	ENE	TRAN	IND	INST	RESID	TUR	CC02	sum
1. No Poverty	1	3	3	1	-1	1	3	1	0	3	4
2. Zero Hunger	3	1	3	0	-1	-3	1	3	0	3	-3
3. Good Health and Well-being	3	3	3	-3	3	1	3	3	3	3	4
4. Quality Education	1	3	1	-3	-1	0	3	0	1	1	-1
5. Gender Equality	0	1	0	-3	-3	-3	1	-1	0	0	-8
6. Clean Water and Sanitation	3	-1	1	3	-3	-3	0	3	0	1	-4
7. Affordabel and Clean Energy	1	1	1	3	3	3	0	3	1	1	10
8. Decent Work and Economic Growth	3	3	3	1	1	3	3	3	1	3	8
9. Industry, Innovation and Infrastructure	3	3	3	1	3	3	1	1	3	3	10
10. Reduced Inequality	3	1	3	0	0	-1	3	0	0	3	0
11. Sustainable Cities and Communities	3	3	3	1	3	3	0	3	3	3	10
12. Responsible Consumption and Production	3	3	3	3	-1	0	0	1	0	3	5
13. Climate Action	3	3	3	3	3	-1	0	0	1	3	8
14. Life Below Water	3	-3	1	-3	-3	-3	0	0	0	1	-12
15. Life on Land	3	-3	3	-3	-3	-3	1	1	3	3	-12
16. Peace and Justice Strong Institutions	3	0	0	0	0	0	3	0	0	0	0
17. Partnerships to achieve the Goal	3	3	3	1	1	1	3	3	3	3	6

Scale of Evaluation		
Most benefit	3	#7030A0
Benefit	1	#CC66FF
Neutral	0	#BFBFBF
Detriment	-1	#FFFF00
Most Detriment	-3	#FF9933

Fig. 6. Matrix SDG - Sustainable Development Goals. Source: International Geodesign Collaboration (IGC). https://www.igc-geodesign.org/project-workflow (2021). Adapted by the workshop collaborators).

Through this matrix, after the preparation of the proposals, it is possible to qualify the extent to which the proposals reached the sustainability goals, rating them from -3 to 3, with -3 and -1 being the proposals that did not reach the goals, 1 are the proposals that achieved the objectives to some extent and 3 are the ones that best achieved the objectives.

Most Benefit	Benefit	Neutral	Detriment	Most Detriment
3	1	0	-1	-3

Fig. 7. Matrix SDG rating scale. Source: International Geodesign Collaboration (IGC). https://www.igc-geodesign.org/project-workflow (2021).

Thus, each axis of the sustainability triad analyzed and qualified the proposals of the other two groups, considering the systems linked to them. Thus, the Environmental axis analyzed the proposals of the Economic and Social axes, the Economic axis analyzed the ideas of the Environmental and Social axes and the Social axis evaluated the proposals of the Environmental and Economic axes. In addition, each group analyzed their own proposals.

3.4 The Workshop: Co-creation of Ideas

With the Representation, Process and Impact Models prepared, it was possible to start the workshop. The workshop was organized in 5 meetings of 4 h each, totaling 20 h of activities, within the scope of the Urban Environmental Quality Analysis discipline: integration of thematic data, from the graduate program at UNESP in Rio Claro. From a total of 12 participants, there were 10 PPGG students and 2 UNICAMP graduate students. Due to the COVID-19 pandemic, the event was held entirely through the Google Meet platform. Andréia Medinilha Pancher (UNESP) led the workshop, with the support of Ana Isabel de Sá (IFMG) and Ana Clara Mourão Moura (UFMG).

Participants were divided into 3 groups and were instructed to prepare and defend proposals based on the tripod of sustainability: Environmental, Economic and Social. Each group created a google meet room to work within their axes. Participants were instructed to draw policy and project diagrams for the 10 systems: Vegetation, Hydrography, Housing, Transport, Institutions, Trade/Industry, Agriculture, Energy, Tourism/Culture/Leisure and Carbon Credit, considering the vulnerabilities and potential of the area.

In the 1st meeting, all participants performed the reading enrichment, a stage that allowed knowledge of the 43 layers of data, organized in GISCoLab, as well as the overlapping of layers, for the integrated analysis of information. It is noteworthy that at this stage, it is possible to enter additional information through notes. In the case of the metropolitan region of Campinas, from the integrated analysis of thematic cartographic data, vulnerable areas were identified, considering the environmental, economic and social points of view. Thus, the weaknesses of the Permanent Preservation Areas, due to urban occupation, were discussed; the importance of preserving conservation units, to expand the vegetation area and, consequently, contribute to carbon credits. In addition, the issue of expanding the housing and transport supply (collective transport and the use of smarts) was discussed, adopting more sustainable models.

At the 2nd meeting, employees were separated into three groups: Environmental, Economic and Social, choosing which group they would like to participate in. However, they were also able to give their opinion on the other topics. Next, they were instructed to prepare the proposals without innovations, that is, without looking for new things,

projection in the traditional, taking into account the 2035 and 2050 scenarios. For the preparation of the proposals, project diagrams were drawn (which can be realized in the short term) and policies (intentions, which can be implemented in the long term) using GISCoLab's design resources. It is noteworthy that for almost all systems, dots and lines were used for the preparation of proposals. However, for the Carbon Credit System the ideas were designed using polygons. In the first part, the three groups, gathered in different virtual rooms, made proposals without innovations for the 2035 scenario. In the second part, the groups made proposals without innovations for the 2050 scenario. To allow the development of the 2050 scenario, some actions had to be proposed in the 2035 scenario, receiving adjustments and selecting the most interesting annotations.

At the 3rd meeting, the groups made proposals with innovations. In the first part of the meeting, all participants made proposals with innovations for the 2035 scenario, based on enriching reading. For all the workshops, a 30% increase in vegetation was defined as a goal, adding to the proposals of the 2035 and 2050 scenarios. For that, it was necessary to propose an increase in carbon credit through the conservation of areas with robust fragments and that they need maintenance and investment to maintain themselves properly; expansion in areas with fragments, but in need of improvement in their conditions; and, creation of green areas, where there is no vegetation, but which are able to be implemented. In the 2nd part of the meeting, all participants made proposals with innovations for the 2050 scenario, based on the 2035 proposals. The groups were able to use ideas from existing innovations on the International Geodesign Collaboration (IGC) event website (igc-geodesign) (igc-geodesign.org/global-systems-research), as well as had the opportunity to suggest their own ideas, based on their research or professional experiences.

At the 4th meeting, participants created ideas with many innovations for the 2050 scenario, being able to continue the 2035 proposals. In addition, they were able to extract ideas from the IGC website for the 2050 scenario, adapting them to the Brazilian reality, in specific, the Metropolitan Region of Campinas (Fig. 8).

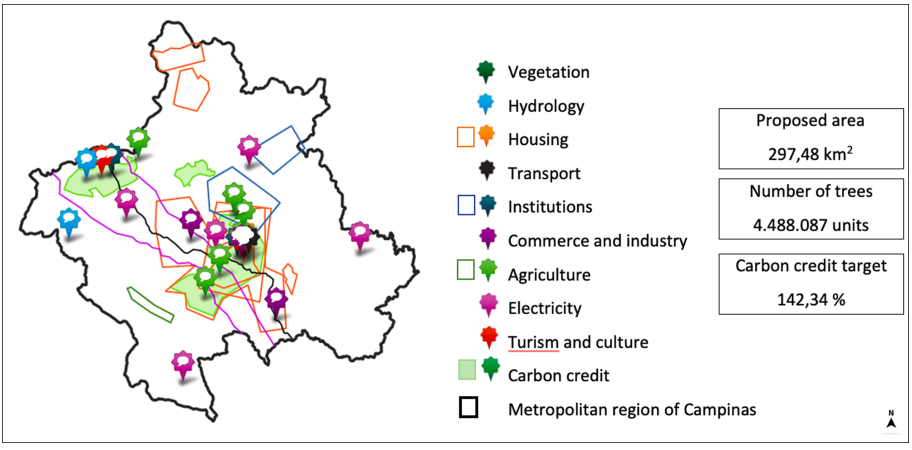

Fig. 8. Final scenario. Organization: the authors.

Once the diagram design step was completed, everyone voted on the proposals created for all systems, using the Like and Don't Like feature, available on the GISCoLab platform. In addition to voting, participants were able to add comments to each proposal, in order to clarify the reasons for voting against or even proposing adjustments or changes to the location of the approved proposals.

During the activities, analyzing the development from the 1st to the 4th meeting, an evolution in the preparation of proposals was evidenced, from 43 proposals without innovations to 47 proposals with many innovations, highlighting that many ideas built in the scenarios with innovations were taken advantage of, continued and improved.

The proposal analysis stage (5th meeting) proved to be fundamental, as it allowed everyone to know all the ideas developed by the three groups, as well as making a critical analysis of the weaknesses and potential of collective creation. Taking into account the scenario without innovations, with innovations and even with many innovations, the groups showed that the collective construction of ideas occurred in an evolutionary way, allowing for the expansion of proposals and better achieving sustainability goals.

In addition to the positive aspects identified by the groups, the weaknesses of some themes were also highlighted. With regard to gender equality, the social group noted that no proposals were made to address the vulnerability of specific social groups. Also, ideas were developed for the modernization of housing, in order to alleviate physical and natural problems, such as thermal comfort, issues related to slope, etc., however, there was a lack of proposals for the construction of new housing for the part of the population that is not assisted.

The Economic group also made a critical analysis of the proposals. Regarding the goals for reducing poverty, hunger, gender equality, that is, social aspects, the group also identified weaknesses. For example, innovations in the means of transport (vehicles powered by solar or electric energy) were proposed, but the issue of harassment that occurs in public transport towards women was not considered. As a solution, they could propose the separation of public transport, serving only women. It should be noted that social proposals like these would require a broad debate in society. For the scenario without innovations, it was evident that the adoption of traditional, non-innovative proposals resulted in ideas that were not linked to the three axes: Environmental, Economic and Social, that is, without establishing inter-relations. In this sense, the economic group gave great importance to agricultural issues, such as the proposal for urban gardens, but the impact that such actions may have on animals living in areas where gardens will be implemented were not considered.

In the analysis of the proposals by the Environmental group, based on the scenario with innovations, positive effects on health, well-being and gains in the issues of poverty and hunger were highlighted, through actions related to the implementation or improvement of infrastructure (sanitation, for example), climate, reflecting in improvements in water quality, in the expansion of carbon credits, among others.

Regarding the proposals for the vegetation system, the environmental group highlighted the recovery of riparian forests along the drainage network and, mainly, around the springs; suggested the interconnection between conservation areas, through the establishment of flora and fauna corridors. Also, urban afforestation on sidewalks, as well

as the implementation of Environmental Protection Areas and Areas of Relevant Ecological Interest (ARIE), which can be some massive forests existing in cities or even isolated trees. In addition, green roofs were proposed, the transformation of urban voids into urban gardens. These proposals directly reflect on the volume and quality of water and on the Carbon Credit. For the water system, the group proposed the reduction of charges for its use for those who implement the collection and use of rainwater and for industries that develop technologies for the reduction and rational use of water. In urban areas, integration of vegetation with buildings and water retention in public, residential and commercial buildings. Also, the elimination of areas of diffuse contamination, which contaminate underground water tables, in addition to greater control of polluting sources. In rural areas, the implementation of drip and digital irrigation.

The economic group presented proposals for the use of photovoltaic panels in 50% of homes in the MRC; expansion of the use of solar energy on highways, providing the neediest population living in the surrounding area with energy generated at a reduced cost. In addition, the generation of energy from natural waterfalls in rivers, without the construction of reservoirs; this type of power generation involves low investment. Also, implementation of Power to Gas plants (electrolysis and hydrogen process) throughout the region. In addition to these ways of generating energy being sustainable, it would allow the metropolitan region of Campinas to be self-sufficient in the production of electricity. Another proposal of the group was related to family and organic agriculture, which includes ecological pest control, with support from the government. Thus, green roofs were suggested for the implementation of urban and community gardens. Another proposal was the creation of a family farming program, with credit lines.

With regard to industry and commerce, encouragement of innovation for all industries in the MRC and implementation of intelligent infrastructure in the streets of central businesses, integrating tenants and customers through a quality virtual connection. Include small traders in the Magnetic Levitation Transport (MAGLEV) system, paying lower rents and allocating stations. For transport, the group proposed expanding MAGLEV and creating new stations to serve more municipalities in the MRC.

The Social group proposed the implementation of smart windows in all constructions. In the health area, the idea was to implement virtual care, through the direct connection of the patient with doctors and databases and remote examinations (reduction in waiting time, travel and transport costs). In relation to the transport system, the idea was to increase tax incentives to electrify 100% of the public and private vehicle fleet, as well as for mass transport and the consolidation of urban cycle paths. Also, the use of the solar highway.

For tourism, the consolidation of Glampings in natural areas with replicable structures inspired by nature, brings the idea of natural design, encouraging environmental tourism and conservation of the area. In addition, the creation of self-sufficient stadiums in water collection and treatment, solar energy production, and sewage treatment, with multiple entertainment functions. For rectified and channeled urban rivers or streams, remove the concrete or pavement that are covering the waterways, restoring them to their original condition, allowing the creation of parks close to these areas and the expansion

of systems leisure activities for the population. For the water supply network, insert sensors in all public and private buildings and in the water transport network, connecting them to an online central.

For the housing system, it was proposed to replace concrete with materials that contribute to lowering the temperatures of cities. Another idea was the implementation of green streets in the urban perimeter with the objective of increasing the vegetation, constituting a necessary measure to meet the carbon credit and improve the quality of life of the population of the MRC, which lacks urban green. For transport, it was suggested the expansion of tax incentives to electrify 100% of the public and private vehicle fleet, encourage mass transport and consolidation of urban cycle paths.

Given the above, the evaluation process served to analyze the proposals together, reflecting on the possibilities of adaptations, adjustments and adjustments, allowing for the improvement of ideas, making them more effective and coherent with the reality studied.

4 Conclusions and Discussions

The results obtained at the workshop demonstrated the potential of the Geodesign methodology for territorial assessment and planning, allowing the analysis of a large volume of thematic data from the MRC, in an interrelated way, enabling the elaboration of proposals to mitigate vulnerabilities and take advantage of potentialities of the area.

It is a methodology that favors and encourages teamwork, allowing for the enrichment, complementarity and integration of proposals. Through the dialogues established in the meetings, all participants had moments of speech, enriching the elaboration of proposals with different academic and professional experiences, favoring critical analysis.

In addition, during the meetings there was an evolution of the proposals, allowing for surpassing the established target of 30% of carbon credit. For the 2050 scenario with innovations, there was an increase of 96.54% of CCO_2, which can be explained by the low vegetation index in the MRC, which led the group to create more proposals for this System.

The evaluation stage of the proposals proved to be fundamental, as it served to think about possibilities for adaptations/adaptations, allowing for the improvement of ideas, making them more effective in alleviating the problems of vulnerabilities and making better use of the potential of the analyzed area. Thus, it is suggested that this evaluation step be carried out before the closing of the proposals.

The groups made proposals within their axes, but many have an interface with the other axes as well, evidencing the existing integration to achieve sustainability. It should be noted that several innovative proposals for the 2050 scenario can only be implemented if they are started in the 2035 scenario, as they require time to develop, mature and consolidate, as is the case with the implementation of vegetation.

The Geodesign methodology offers the opportunity for everyone involved to present their ideas and to listen to the proposals of others, favoring teamwork, generating an enrichment of ideas, expanding the possibilities for actions, enhancing the adequate planning of the territory.

An important aspect highlighted by the environmental group is that this work dynamic, of co-creation of ideas, allows the integration of knowledge between professionals from different areas, resulting in collective proposals, therefore broader and more complete, taking advantage of the experiences of all involved.

Furthermore, it is important to point out that Geodesign allowed an evaluation of territorial data and the elaboration of proposals in a democratic way. The GISCoLab platform is a very important contribution tool for collaborators to enter information in order to create a critical/analytical scenario in relation to the data that were initially fed by the organizers.

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