

Decision Making and Geodesign: A Collaborative Territorial Planning Proposal for the Metropolitan Region of Belém, Pará, Brazil

Alan Nunes Araújo(✉), Tiago Barreto de Andrade Costa(✉), Bruno Daniel das Neves Benitez(✉), Fabricio Martins Silva(✉), and Joabi Luiz Lima De Lima(✉)

Federal University of Pará, Belém, Brazil
alanaraujo@ufpa.br, joabi.lima@ifch.ufpa.br

Abstract. This paper is the result of a case study based on the geodesign proposal (Steinitz 2012) adapted to the metropolitan reality of Belém, Pará, Brazil. Composed of seven municipalities and with about 1.7 million inhabitants, this metropolitan region is the second most populous in the Brazilian Amazon. Paradoxically, even in the midst of high rainfall, a dense hydrographic network and an abundance of water resources, Belém shows significant vulnerability in terms of the quality and quantity of water accessed by its population. According to the Sanitation Panel, 39.8% of the population in the Metropolitan Region of Belém (MRB), does not have access to drinking water (Brasil 2018). In turn, 90.1% do not have sewage collection and treatment, further aggravating the water crisis, socioeconomic and health inequality. This reality requires more effective urban planning with regard to the vulnerabilities presented. In this scenario, geodesign represented an interesting methodological approach, primarily for highlighting the importance of the water issue in Belém and also for sketching propositional scenarios, in a collaborative way and based on Geographic Information System (GIS).

Keywords: Territorial planning · Geodesign · GISColab · Pará

1 Introduction

The metropolitan regions integrate between their cities a series of relations of dependence and centrality materialized in continuous or discontinuous flows of urban services that occupy, in turn, the same territory, requiring a shared management of these spaces and inter-municipal articulation for greater functioning and mobility, less environmental impact and conflict reduction. The Brazilian Federal Constitution, promulgated in 1988 brought the state as a major interlocutor of development policies and urban and rural planning in the country, triggering the emergence of important laws that address related issues to planning, such as the 9433 Law in the year 1997 that instituted the national

© Springer Nature Switzerland AG 2021
O. Gervasi et al. (Eds.): ICCSA 2021, LNCS 12954, pp. 420–436, 2021.
https://doi.org/10.1007/978-3-030-86979-3_30

Water Resources Policy until Law 10257 in 2001, that established the general guidelines of urban policy and more recently Law 13089 that institutes the Metropolis Statute.

In this context, according to Rocha et al (2016), the propagation of a discourse and actions favorable to the territorial approach to development and public policies associated with national, regional, and local levels is increasingly evident. Therefore, it is necessary that Planning, to be effective, is not incarcerated in the deterministic ideal and that has as its essence, predictability (Camargo 2009). Therefore, it is necessary, in addition to Planning, a greater ordering of the information that make up the Territory, fostering a vast field of analysis and spatial projections and forecasts.

In this respect, Geodesign fits within an innovative and important area in terms of thinking, planning, and designing the region, considering that it appears as a large set of issues and methods necessary to solve complicated and significant problems at different geographical scales (Steinitz 2012). The spatial complexity, seen until then in various phases of regional planning as obstacles, in Geodesign become an important stage within a collaborative proposal, complementing knowledge and defining priorities.

In this approach, the opinion of the actors involved in the process, that is, people who live, know and use the studied territory, gain prominence and will be fundamental to draw spatially and plan better and closer to the real from a collaborative perspective and that can assist more sustainable and democratic decision-making. The geovisualization is also relevant part of the process because it will provide a collection of spatial information that will make systems, and therefore assist in political proposition and interventions in space. Therefore, the practice of G eodesign requires collaboration between professions of environmental design, geographic sciences, information technologies and local people (Fig. 1). (Steinitz 2012).



Fig. 1. A framework for geodesign

The Specialist responsible for planning, in this perspective, will no longer be the author of the idea, but, from listening, the decoder of the collective will and for that, it becomes essential to materialize methodologies, such as those proposed

by Geodesign so that the collective establishes priorities, and the planner better meets expectations. Among the methodological scripts of Geodesign, the one proposed by Steinitz (2012) is perhaps the closest to collaborative listening (Fig. 2), as in a Workshop format it is divided into six models and which in turn will be subdivided into two phases. The first, more technical and not necessarily with consultation with society, will be responsible for the survey, treatment and organization of spatial information grouped through Systems giving shape to the Models of Representation, Process and Evaluation. Subsequently, the second stage, more practical, will take place during the participatory planning workshop, which will involve the various actors that make up the territory to be planned, forming the last three Models (Change, Impact and Decision). (Moura 2019).

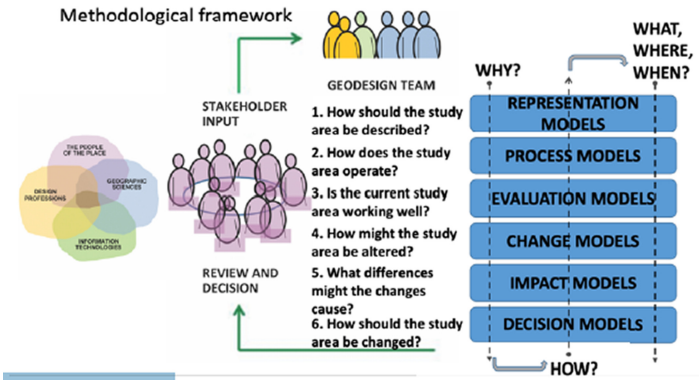

Fig. 2. Geodesign framework

This methodological proposal in Workshop format was conducted in Brazil by Professor Ana Clara Mourão Moura from the Federal University of Minas Gerais and involved several Brazilian Federal and State Universities such as (UFMG, UFRRJ, UFJF, USP, UFCE, UFPE, UFG, UFPA, UFT, UNIFAP, UDESC and UNESP of Rio Claro) as well as two planning departments (SEMA-AP and SETRAP) with the objective of composing a global experiment proposed by the IGC[1] in which, based on collaborative planning, he studied and planned interventions in different scenarios for Metropolitan Regions between the years 2035 to 2050 through the GISColab platform. The article in question intends, therefore, to describe the collaborative territorial planning proposal for the Metropolitan Region of Belém, Pará, Brazil. through the Geodesign.

2 Geographic Location

The Metropolitan Region of Belém (RMB) has an area of 1820km^2 and is composed of seven socioeconomically integrated municipalities (Belém, Ananindeua, Marituba, Benevides, Santa Bárbara do Pará, Santa Izabel do Pará and Castanhal) being the capital

[1] https://www.igc-geodesign.org/.

of the state of Pará, Belém, the most populous municipality and economic and financial center of the State, but geographically limited by its semi - peninsular condition surrounded by Guajará Bay and the banks of the Guamá River (Fig. 3), reverberating today, in an intense process of expansion and vertical urban to towards the other municipalities that follow the axis of the highway BR 316 (final stretch of the Belem-Brasilia highway) and it will be detailed later in this article. Ananindeua and Marituba have been expanding to a large extent with the function of sleeping cities for significant contingents working in Belém.

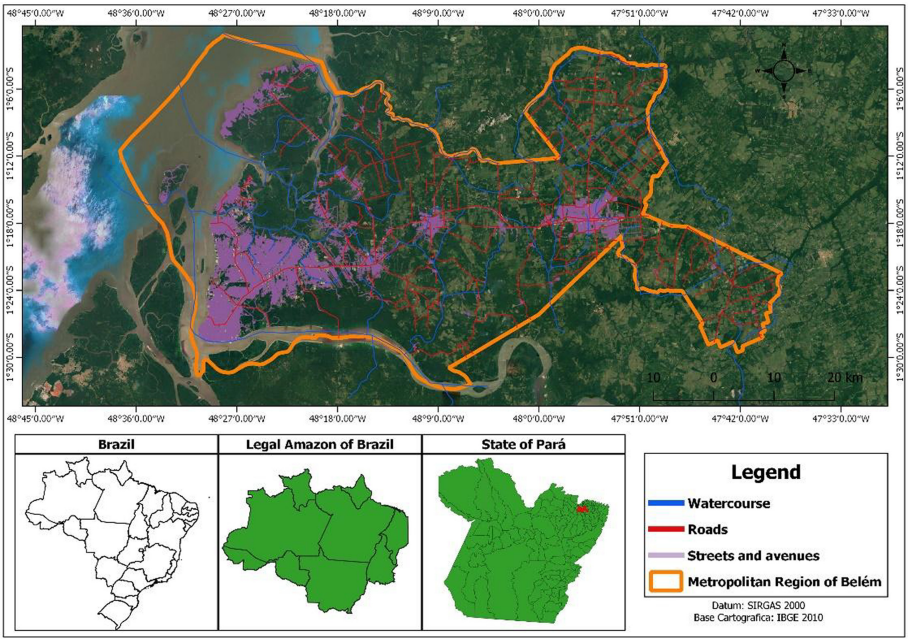

Fig. 3. Metropolitan Region of Belém (MRB), Pará, Brazil Source: IBGE 2010.

All the MRB, inserted in the Amazonian domains (Fig. 4), had, in 1985, an area of 61.32% of Forest, reducing to 51.62% in 2000 and in 2019, 46.72%. In contrast, the Farming class in 1985 occupied an area of 16.68%, growing to 23.47% in 2000, and in 2019 26.77%. This growth also followed the Non-Vegetated Area class, which in 1985 occupied 4.31%, in 2000 7.04% and in 2019 8.78%. These values justify, despite the high number of forest areas, a high tendency to change this class to others, mainly pasture or urban area, present in the Non-Vegetated Area class. These changes reflect not only the environmental impact on the Amazon ecosystem, but also on the living conditions in the "Metropolis of the Amazon".

The RMB has a population of 2,101,883 inhabitants, of which 66% constitute the 1.4 million inhabitants of Belém. RMB concentrates approximately 40% of the wealth produced in the State and 35% of the entire population of Pará (IBGE 2010). Except for Santa Bárbara, with 32% of the urban population, all other municipalities have their

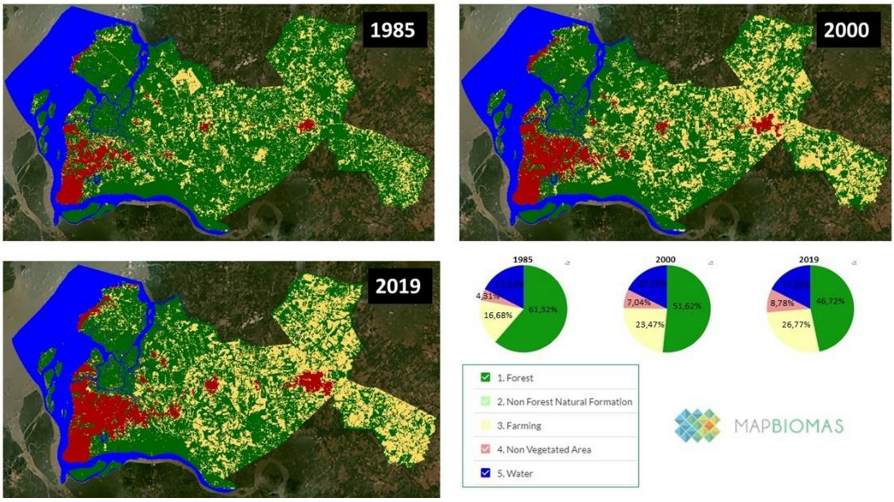

Fig. 4. Land Use and Coverage in the MRB 1985, 2000 and 2019 **Source:** Project MapBiomas Alerta 2021

inhabitants predominantly residing in the municipal headquarters. The highest rates of this reality are concentrated in Belém, Ananindeua and Marituba and Castanhal, where practically the entire population is in the headquarters.

The so-called first heritage league of Belém is a piece of land approximately one league away from the city's founding landmark, donated in 1627 by the Portuguese crown to the municipal administration, as a domain over which the city should expand (MUNIZ, 1904). Until the 1980s, the expansion of Belém practically occurred within the framework of this limit (Trindade Jr. 1999). In fact, it is only in the institution of the 1993 master plan that the official urban space of Belém is extended to more distant parts of the municipality and towards the other municipalities.

Due to the occupation centered until recently in the domains of Belém, the first league is the area of the city that concentrates the highest population density, which is not homogeneously distributed in its interior. The largest population concentration, as can be seen in Fig. 4, is represented by the so-called "lowlands", areas located in altimetric levels more subject to flooding, which were occupied throughout the formation of the urban space of Belém, predominantly by populations of lesser power acquisitive (Trindade Jr 1999). Therefore, these areas of more floodable soil and of high population density, represent the oldest peripheries of the urban space in Belem, and this condition will multiply throughout the other municipalities of the RMB more recently, with residences on irregular street layouts and close to the channels (water courses), showing spontaneous occupations and without urban planning (Fig. 5).

The physiographic characteristic of the urban site of Belém will also dictate the socio-environmental problem that involves these lowland areas. Geomorphologically, a significant portion of the RMB's territory is located on fluvial plains, represented by tributary floodplains of Guamá and Guajará Bay, which is constituted in an estuarine region approximately 100 km from the Atlantic Ocean.

Despite the distance to the ocean, due to the peculiar characteristics of the great mouths of the Amazon basin, the urban site of Belém is affected by the tidal cycle, which enters several kilometers in the rivers of the Amazon. Thus, daily the high tide retains the outflow of the water courses that cut through the city, increasing its levels. Such a process becomes more intense at high tides (tides of the moon).

In parallel to this fluvial and geomorphological dynamics, RMB is traditionally known for its frequent and high rainfall. It rains with almost daily frequency, mainly between the months of January to April. Several of these rain events have torrential characteristics (Fig. 5).

It is in this physiographic context that the urban space of the study region is inserted. The lowlands, in turn, are the most vulnerable portions to this water dynamic, because in addition to being found in the lower elevations, they are also the areas of natural flooding of the water courses that flow into Guamá and Baía do Guajará.

In addition to this, the intense waterproofing process of urban soil, which naturally already has deficiencies in its vertical drainage, since it is formed by a hydromorphic pedology (of floodplain), further aggravates the picture of constant and frequent flooding of the lowlands (Fig. 5).

Due to these characteristics, the socio-environmental and sanitary occupation of these floodplains, requires and since the beginning of the occupation, significant technical interventions to control the tide, urban drainage, sanitary sewage, among others. Such interventions are such that until the rubber cycle, authorities, and elites, in the process of official occupation of the city of Belém, chose to avoid low-lying regions.

On the other hand, the poorest populations, immigrating from riverside regions to the RMB, largely occupied these wetlands, not only because of the greater adaptability to fluvial and rainfall variations, but mainly because these areas did not arouse the interest of the real estate sector, therefore, liable to occupy spontaneously and informally. In yet with the process of urban density and without an adequate presence of the government, new problems have emerged: sewage, garbage collection, urban accessibility, violence etc. L Evando such areas today accumulate various social disadvantages.



Fig. 5. City of Belém - Pará **Source**: Eloí Raíol 3D, Folha Uol, O liberal

Thus, in contrast to the lowlands, the regions of "firm lands", that is, with higher altimetry (greater than 4 m), with a lower demographic density, they are, therefore, in addition to less humid areas, those that shelter the populations wealthier (TRINDADE Jr, 1999). Its structure of roads and public spaces represents what was made effective by the official plans for the expansion of the urban network, set in motion throughout the various cycles of spatial production in the city of Belém (PENTEADO, 1968). In these areas, the blocks and streets have more regular formats, expressing the planning in the layout.

In the parts of the oldest occupation of the firm lands it is where the most verticalized portions are found, the result of transformations that have been occurring in the last decades (oliveira et al. 2005). The intensification of building incorporations, increasingly tall and always with non-popular standards, shows a spatial restructuring in the housing trends of the population with the highest purchasing power, located in these drier lands of the first heritage league (oliveira et al. 2005). Figure 5 highlights the referred vertical area on the "firm lands" where a significant portion of the current Belenese elite resides, and which will also be repeated in the other municipalities of the MRB.

This phase is approximately from the 1980s to the present day, mainly following the highway axes of BR-316 and Rod. Augusto Montenegro (TRINDADE Jr. and LECIONE, 1998). Figure 3 shows the population growth and expansion of the urban area from the early years of this phase to the present day. It is possible to see in more detail how the metropolitan dispersion referred to by Trindade Jr. and Lecione (1998) took place.

In this new framework of transformations, the form of expansion of the periphery with occupation of the lowlands of the first heritage league, which give rise to what Cardoso et al. (2015) called the nearby periphery, it begins to give way to another process of peripheralization, that of distant peripheries, which spread in expansion of the city, after the institutional belt and in the direction of Ananindeua.

Basically, the production of this new peripheral spatial structure, in addition to the institutional belt, was guided by the following logic: the lands immediately next to the Augusto Montenegro Highway were reserved by developers and landowners as a value reserve to be built in a second moment intended for to the more affluent social classes (Cardoso and Ventura Neto 2013). Behind these land reserves, the government has built popular housing projects since 1970 (Cardoso and Ventura Neto 2013). The interstices of these formal groups were being occupied irregularly by precarious forms of housing that today constitute the spatial expression of what Cardoso and Ventura Neto (2013) are calling distant peripheries.

We also draw attention to the southeastern portion of the expansion area. This is where most of the popular housing estates are concentrated and where, especially since the mid-2000s, there has been the installation of housing and urban equipment along the Augusto Montenegro Highway, aimed at the population with the greatest purchasing power. It is the construction of more exclusive spaces in areas previously reserved by the real estate market (Cardoso And Ventura Neto 2015). In this way islands of lesser social vulnerability are being created in the production of this expansion space in the city of Belém. In this process, the intense replacement of the areas of Native Amazon Forest by the expansion of the urban network stands out.

The fact that Belém was born with an eminently urban function of commerce and territorial dominance of the Amazon, a function that it still maintains today, bequeathed to the municipality an inexpressive rural space in its immediate surroundings, practically nonexistent. In this way, the expression of the urban transition that Brazil experienced in the last century, meant in Belém, not a demographic inversion of a rural population for an urban population, but, an exponential increase in its urban population contingent that occurred mainly due to the migration of people from other parts of the Brazilian territory.

With the expansion of the urban ax of Belém over most of its continental area, with the exception of some forests, nowadays, in addition to the predominantly urban population, its territory is also clearly covered by the urban, but with vast growth potential towards the municipality of Castanhal. This in turn, marked by nuclei of concentration of wealth, circumscribed by vast extensions of precarious areas in terms of infrastructure, housing, accessibility, public security, among others.

3 Tools and Methods

For implementation of the Workshop Geodesign on the metropolitan region of Belém, was used technology GISColab, Brazilian platform Geodesign developed by UFMG, based on the SDI standard (Spatial Data Information) and OGC to consumption data via WMS or WFS, allowing both the cases the performance increase by WPS (Web Processing Service). In this sense, on the first day of the event, a collection of official maps was made available to the Workshop participants, organized by the Geoprocessing Laboratory of the UFMG School of Architecture and Urbanism by Systems, which make up the first stage proposed by Steinitz (2012) in which the Spatial information is associated with the Models of Representation, Process and Evaluation. In turn, the second stage is actually the materialization of the Workshop and divided into 4 parts (Fig. 6):

The steps described above were developed in four virtual meetings, during the month of April 2021. Initially 9 participants were part of the team, but during the process there were withdrawals and ending on the last day with 5 participants, the same from the beginning to the end. and composed of professors from the Federal University of Pará, students and researchers who study the Metropolitan Region of Belém. Due to the small number of people, it was not necessary to divide into other groups, remaining the same in all phases involving the collaborative planning proposal of the RMB until the year 2050 added to the carbon credit planning for the same region. Thus, the meetings took place as follows:

3.1 Day 1 – Enrichment of Reading and Creation of Notes

After individual consultation of the material (videos, books, and articles) made available by Professor Ana Clara explaining all the concepts related to Geodesign, the participants were received with a succinct explanation of the Workshop proposal and later they listened together to the video that explained the phase of the Enrichment of Reading and creation of notes. At this moment, the mediator also explained about the GISCOLAB platform and the data that would be used in this stage. Thus, the first activity

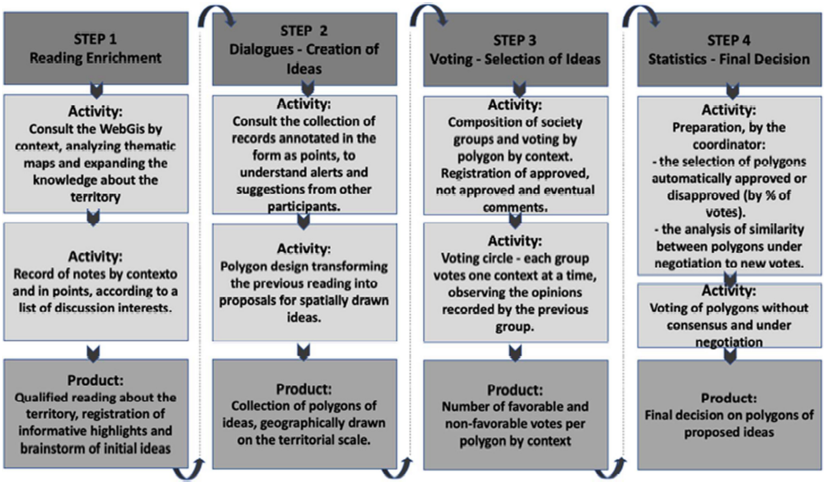

Fig. 6. Operational architecture of the Geodesign Workshop Source: Moura; Freitas, 2020

consisted of handling the platform and consulting the cartographic base, grouped by systems.

The first activity proposed was reading the platform, understanding the layers and taking notes on problems and potentialities. The meeting started with the reception of the participants and an explanation of the general aspects and objectives of the workshop. Subsequently, the participants were distributed in each of the groups, where they would be guided by a "mediator", in charge of explaining in detail the platform and the existing data and assessing whether they would be relevant to assist in the creation of the notes. It was collectively defined that data insertion was missing to aid the analysis. Thus, the participants inserted the cartographic base of the Agrarian Reform Settlements into the platform, in addition to updating school points, hospitals and the Federal Government's Minha Casa Minha Vida program.

At the end of the first moment, in a collective and collaborative way, the participants opened for discussion, pondering the systems and maps that deserved more evidence within the context of the MRB. After some time, they started to insert notes related to this spatial information (Fig. 7), however, closer to the individual experience and experience, a step not only necessary for data analysis, but also for the use of these notes in later activities that involve planning. The reference of colors and symbols was made available through a Table of Notes by the organizing team of the Workshop.

3.2 Day 2 – Creation of Proposals with the Continuation of the Existing Planning

The second day as c atom the first, had an initial explanation of the mediator, and then the team began the planning phase and propositions the years 2035 and 2050 for the Metropolitan Region of Belém, but following the traditional planning "non- adopter". In this sense, a planning without innovation and closer to the Brazilian and regional reality was followed. Thus, the participants started the annotations, inserting in the system the

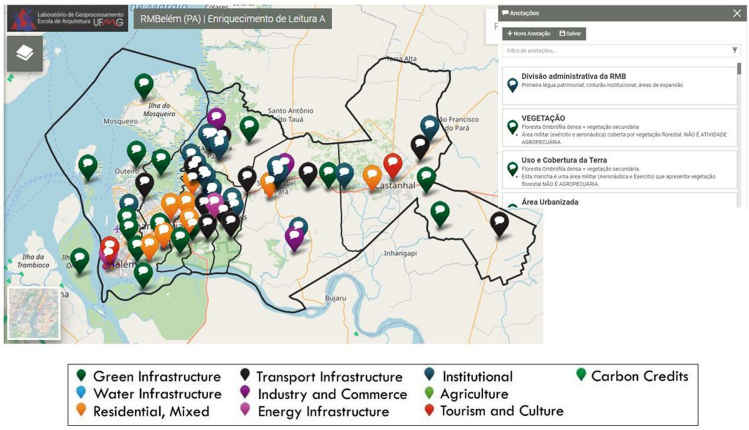

Fig. 7. Result of the first day of the workshop – GISColab platform Source: The authors, 2021.

annotations related to the creation of proposals related to various issues that involve the limitations and potential of planning the RMB.

3.3 Day 3 – Creation of Proposal with Some Innovations

The third day, with participants more accustomed to the platform and Geodesign, began with the creation of proposals for the RMB, as did the second day, however in a more innovative planning concept, the "late adopter". In this regard participants were encouraged by the mediator to establish proposal of great local and regional impact, even if a financial and technological support necessary also higher. The objective of this stage is precisely to think of the RMB for the years 2035 and 2050 with innovations and many innovations, not only in relation to changes in the territory, but also in the establishment of forest areas for the preservation, creation, and expansion of carbon credit.

The objective of this dynamic is to simulate in the period 2035–2050, what changes the territory would experience in the form of planning, adopting measures of innovation. It was hoped that two scenarios could be compared: starting from an existing reality (2021), the year 2035 arrives with traditional planning and, from the year 2035 to 2050, the planning would begin to adopt more innovative forms, being created in a different way. moderately restricted and not what would be possible to implement in fifteen years.

The creation of the proposals remained the same as in the previous dynamic, with point, line, and polygon, with the polygons representing the proposals related only to the " carbon credit" system. To assist in the innovative proposals, it was suggested to consult the existing bank of ideas on the website of IGC - International Geodesign Collaboration, 2021.

3.4 Day 4 – Creation of Proposal with Many Innovations and Voting

On the last day of the Workshop, the team met to collectively think of the RMB in an even more innovative way, "late adopter" for the year 2050. For this purpose, it was

necessary once again to consult the innovative proposals suggested by IGC - International Geodesign Collaboration. In addition, the participants consulted in the days before this last stage, proposals also related to the concepts of Smart Cities, with the objective of improving and innovating the creation of proposals and more directed to the Amazonian reality. In addition to these proposals, the group continued to delimit areas for the carbon credit stock and the respective quantification for the RMB.

After the end of this activity, the participants went for an analysis of the main proposals within a new perspective of the Metropolitan Region of Belém and finally, an evaluation of the stages and knowledge learned in the Workshop.

4 Results

4.1 Workshop de Geodesign: Propostas de Intervenções Urbanísticas Para a RMB Em 2035 E 2050

The "Creation of proposals with the continuation of the existing planning" stage made it possible to think and create interventions for the RMB for the year 2035 and 2050, but in a more conservative way and without technological innovations. The result that was achieved within the collaborative planning was interesting and appropriate to the local reality. Thus, as some examples, proposals were launched for a new location of the Sanitary Landfill, considering the current sanitary and environmental standards. Proposal for the creation of highways, aiming to reduce the flow of vehicles on the main roads and streets of RMB. As it is an economically vulnerable region and in full population growth, the disorganized urban expansion generates pressure on natural areas, with water, even located in the Amazon, the most worrying element in relation to this issue, since according to the Ministry of Cities (201 7) 39.8% of the MRB population does not have access to drinking water. In turn, 90.1% do not have sewage collection and treatment, further aggravating the water crisis, socioeconomic and health inequality, and the need for effective urban planning. So, they were elaborated also proposals for the creation, expansion and technological overhaul of Water and Sewage Treatment Plants. Another recurring problem in the RMB is the flooding points, either due to the action of the tides, or even due to the high rainfall. In this sense, were propose the creation and maintenance system of dikes, formed by channels and sluices automatized the s and integrad the s tidal information and climatological to reduce points of flooding in flood urban areas. In addition, it was also proposed to create channels for draining rainwater.

Moving forward in the proposals for the respective years (2035 and 2050) but at the stage of Creation of proposal with some innovations (Fig. 8), we prepare innovative proposals, to turn the MRB into a Smart and Sustainable Region. As an example, in this phase of the Workshop, the participants proposed the installation of residential wind turbines, in which the system uses solar energy and air flows throughout the buildings and converts them into electricity. Water Retention Parks have also been proposed to take advantage of water surplus from the concentration of rainwater for domestic and commercial use. It was also proposed to create the APA of the Belém-Barcarena Islands, in that area there are large remnants of Alluvial Rainforests and açai crops. For Tourism and Leisure, the Creation and Expansion of Ecopark s in the Amazon was proposed,

where tourists can have the experience of knowing the Amazon biome in all its potential, at the same time that animals are protected and released into nature.

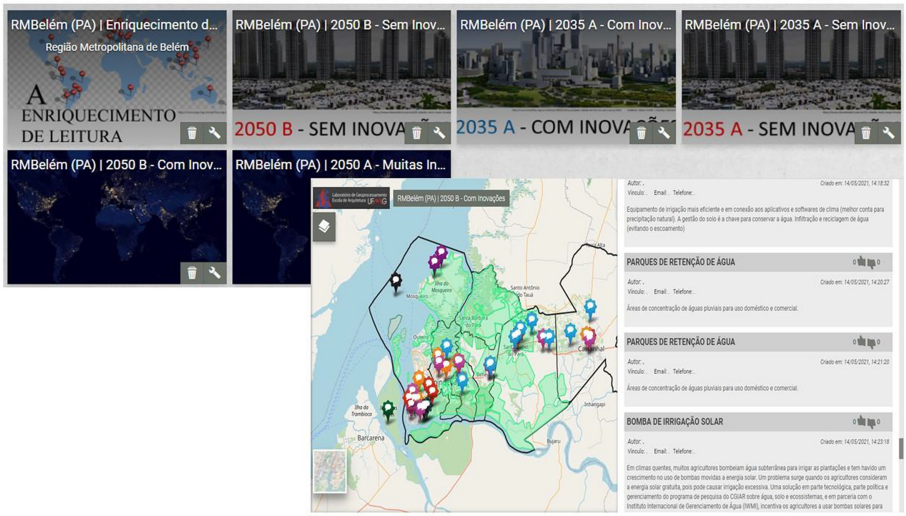

Fig. 8. Creation of proposals with the continuation of the existing planning **Source**: The authors, 2021.

The last stage of urban planning proposals for the RMB for 2035 and 2050 was the Creation of proposal with many innovations and voting (Fig. 9) in which very innovative proposals had been developed. Thus, proposals were made for innovations in air and rail transport (currently nonexistent in the RMB) such as Transportation Networks via Pipes composed of a high-speed train that would circulate through a kind of closed tunnel under the ground, interconnecting the metropolitan regions of Belém.



Fig. 9. Creation of proposal with many innovations **Source:** The authors, 2021.

Automated stations were also proposed, with a facial or digital biometric reader, eliminating tickets and ticket cards. They also proposed the creation of Libraries of the Future, where the physical content is only for exhibition, and the research will be done by voice command and authorized via facial or digital biometrics, and individual and / collective rooms (maximum 5 people) with highchairs. technological power. Carbon installation, with its soils managed to trap carbon and transform its APPs into carbon credit assets.

Construction of vegetated linear corridors along intra-urban channels, contributing to the decommissioning of the hydrographic network. Installation of Floating Wind Farms with the foundation of pure concrete and stuck, at the bottom of the sea or rivers with high flow, with currents. They are so flexible that they can be scaled to any size of turbine. Solar Roads, to take advantage of all potential in Northern Brazil, consisting of modules made of 7mm thick polycrystalline silicone and inserted into the road surface. Port Cleaning Devices, where the river current drives a water wheel that lifts the material from the water and deposits it in a barge, among other equally interesting proposals that allowed planning the RMB of the future.

4.2 Trees for Metropolitan Region of Belém, Pará, Brazil

In addition to the collaborative urban planning carried out at the workshop, there is also, simultaneously, the proposition of favorable areas for the creation, maintenance, and expansion of the Forest areas, also between the years 2035 and 2050, not only within the perspective of environmental conservation, but also aiming to meet the Sustainable Development Goals (SDG) United Nations Organization, which stands out for this study the mitigation of climate change from carbon sequestration.

The Amazon is a key environment for this discussion, given that despite the intense deforestation encouraged by the Brazilian state in the 20th century through the National Integration Plan and nowadays, with the dismantling of the inspection bodies and the lag of a precise and adequate environmental agenda. the global discussions, which in turn favor an exponential increase not only in deforestation, but also in the outbreaks of forest fires. Even so, the Amazon has the largest forest spot on the planet and gains notoriety in this respect for its potential for carbon sequestration. According to Becker (2005):

> What is the Kyoto Protocol if not the air market? It is an attempt to establish carbon emission quotas in heavily industrialized and polluting countries in exchange for maintaining forests in countries equipped with them. The air market is the most advanced. In other words, these real markets try to institutionalize themselves in global forums, which is also a new aspect within international law (Becker 2005).

In this perspective, the Workshop participants sought to analyze and establish a percentage of areas destined for the purpose of the carbon credit stock, according to the definitions of the SDG. Thus, it came to following results (Fig. 10):

Until 2050 they will increase CCO2 in 87.25%, with 45125155 trees: 22077054 conserved, 7168616 added and 15879485 replaced. This is a total of 10267432 MgC of CCO2 above ground and 2491283 MgC below, 5.09 MgC / PC. Until 2050 they will increase CCO2 in 73.41%, with 37956539 trees: 220770534 conserved, 0 added and

15879485 replaced. This is a total of 8636341 MgC of CCO2 above ground and 2095516 MgC below, 4.28 MgC / PC. Until 2050 they will increase CCO2 in 0%, with 4284034 trees: all of them conserving existing areas, none added, and none replaced. This is a total of 974756 MgC of CCO2 above ground and 236514 MgC below, 0.48 MgC / PC.

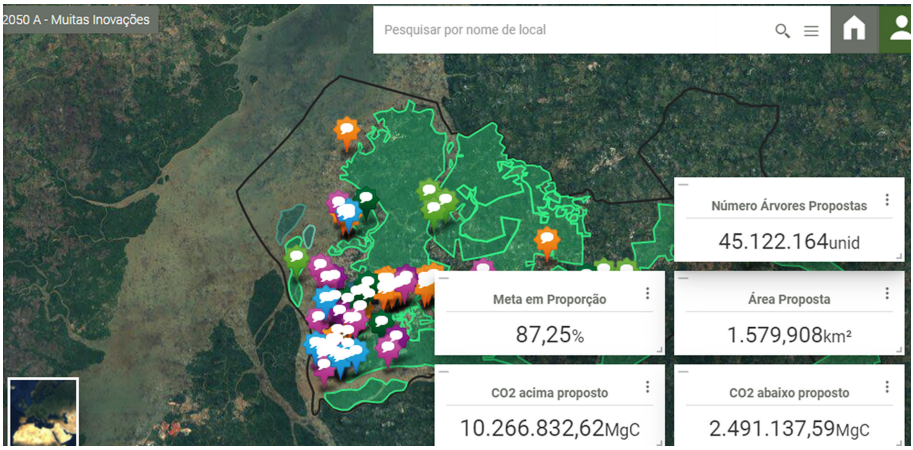

Fig. 10. Carbon credit areas – RMB **Source:** The authors, 2021.

4.3 Final Form on the GEODESIGN Brazil Workshop: Trees for Metropolitan Regions

From the work done, the participants answered a form with the objective of identifying the profile of the participants and the knowledge before and after the workshop (Fig. 11). In this regard, some of the results were that for RMB the team varied between 60% professors at the Federal University of Pará, 20% students and 20% researchers. Of these, 40% already knew about Geodesign processes, 20% did not and 40% are not sure. A relevant fact also concerns their knowledge, before the Workshop, in relation to the region. Thus, 60% already had relevant knowledge, 20% already knew the region fully and 20% are not sure about the subject. Finally, the last graph shows the importance of the workshop, not only for the knowledge of Geodesign, but also for its expansion in relation to the Metropolitan Region of Belém, with 60% being completely sure and 40% with the certainty that the Workshop enabled this expansion of knowledge.

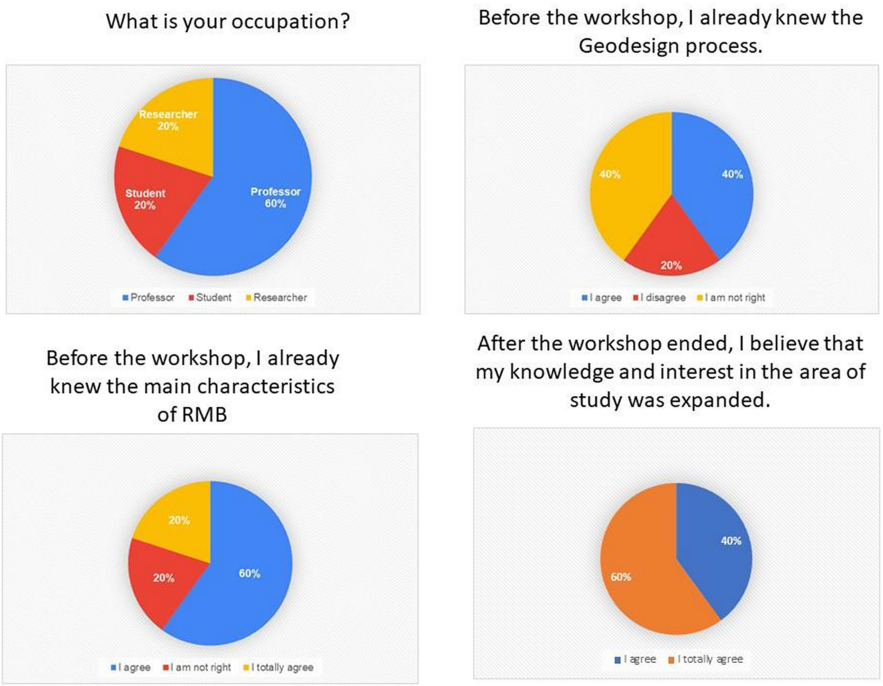

Fig. 11. Profile and Diagnosis of Workshop participants Source: The authors, 2021.

5 Closing Remarks

This article was able to achieve the proposal defined in its general objectives, which consisted of elaborating a collaborative territorial planning proposal for the Metropolitan Region of Belém, Pará, Brazil, through Geodesign. It was found that prior to the Workshop, not all the team understood Geodesign, as well as a lack of more in-depth knowledge about the Belém Metropolitan Region itself. Later, in addition to the knowledge learned, the collaborative planning proposal allowed not only the sharing of thoughts, expectations, experiences, and knowledge among the participants, but it also enabled a new perspective on regional and territorial planning through Geodesign, with information being the central issue of the process, and not just a specific and technical step when planning the space.

It is important to note that despite a process that is broadly democratic and rich in details and information, doubts, and debates about what should or should not be planned also occurred in the process. Thus, on the first day, the doubt that arose in the reading enrichment phase was precisely the need for enrichment of the information itself, since despite the Workshop starting with an official cartographic base and very well organized by the coordinating technical team of the event, more up-to-date details were missing, such as data from hospitals, schools, social housing programs for the low-income population, among others. Participants also identified some classification errors in land use and coverage, mainly with the presence of extensive agricultural areas

within the urban area. Finally, the absence of cartographic bases very necessary for studies in the Amazon was also raised, such as Quilombola Territories, Areas destined to Agrarian Reform and a map, from the altimetric levels, separating the areas from 0 to 2 m of altitude and above 2 m, since despite a physical division, it is also of a social and economic order, mentioned in the work as "lowland" wetland areas and with a predominance of poorer populations and "terra firme" areas, at higher points and with predominance of the middle and upper class. In this sense, with the possibility of entering information on the GISColab platform, participants with more technical experience, updated and inserted information to bring the maps closer to reality for the following activities.

Once this process was done, the other stages of the Workshop were fundamental so that collectively, the participants realized that water is the most necessary element to plan intelligently and sustainably the territory of the Metropolitan Region of Belém. In addition to the rainforests with predominantly Amazonian landscapes, mainly on the edges of the Metropolitan Region and in the islands, the region has a percentage lower than that recommended by the SDG for access to drinking water and sewage treatment. Soon the most critical point becomes in fact the sanitary issue and the pressure of urbanization and agriculture, without planning for the forest regions, many of them recharge areas and fundamental for the water supply for the whole region, such as the Park State of Utinga, an important environmental reserve, but under great pressure from this growth. From this observation, several proposals without innovation, with innovation and with many innovations were also created based on this logic, which also influenced when planning favorable areas for carbon credit.

References

1. Steinitz, C.: A Framework for Geodesign – Changing Geography by Design. Esri Press, Redlands (2012)
2. Instituto Brasileiro de Geografia e Estatística (IBGE). Censo Brasileiro de 2010. Rio de Janeiro: IBGE (2018)
3. Rocha, G.M.; Teisserenc, P. (Org.); Vasconcellos Sobrinho, M. (Org.): Aprendizagem Territorial: Dinâmicas Territoriais, Participação Social e Ação Local na Amazônia. 1a. ed. Belém do Pará: NUMA - UFPA, . vol. 1 (2016)
4. Camargo, L.H.R.: ORDENAMENTO TERRITORIAL E COMPLEXIDADE: POR UMA REESTRUTURAÇÃO DO ESPAÇO SOCIAL. In: almeida, flávio gomes et. al. (Org.). ORDENAMENTO TERRITORIAL. 1ed.rio de janeiro: bertrand, pp. 21–53 (2009)
5. Moura, A.C.M.: O Geodesign como processo de co-criação de acordos coletivos para a paisagem territorial e urbana. In: LADWIG, Nilzo Ivo; CAMPOS, Juliano Bitencourt (org.). Planejamento e gestão territorial: o papel e os instrumentos do planejamento territorial na interface entre o urbano e o rural. Criciúma (SC): UNESC, 2019. Cap. 1.
6. de Palma Muniz, J.: Patrimônios dos conselhos municipaes do Estado do Pará. Aillaud (1904)
7. Projeto MapBiomas Alerta – [versão] - Sistema de Validação e Refinamento de Alertas de Desmatamento com Imagens de Alta Resolução (2021). https://plataforma.brasil.mapbiomas.org/
8. Trindade Jr., Saint-Clair Cordeiro da. Assentamentos urbanos e metropolização na Amazônia brasileira: o caso de Belém. Encuentro de Geógrafos de América Latina, VII (1999)

9. Penteado, A.R.: Belém: (estudo de geografia urbana). Belém: UFPA, 1968, vol. 2 (Coleção amazônica. Série José Veríssimo). Disponível em: http://livroaberto.ufpa.br/jspui/handle/prefix/43
10. Oliveira, J., França, C.F.D., Bordalo, C.A.L.: A verticalização em Belém-Pará, Brasil, nos últimos trinta anos: a produção de espaços segregados e as transformações socioambientais. ANAIS DO X Encontro de Geógrafos da América Latina, vol. 10, pp. 10609–10620 (2005)
11. Trindade Jr., S.-C.C.d., Lecione, S.: A cidade dispersa: os novos espaços de assentamento em Belém e a reestruturação metropolitana. 1998. Tese de Doutorado, Universidade de São Paulo, São Paulo (1998)
12. Ministério Das Cidades: Diagnóstico dos serviços de água e esgotos – 2017. Sistema Nacional de Informações sobre Saneamento 2017. Disponível em: < http://www.snis.gov.br>. Acesso abril (2021)
13. Cardoso, A.C.D., Do Vale Gomes, T., De Melo, A.C.C.: Respostas da Concepção atual de regulação urbanística aos Desafios socioambientais de Belém (PA). InSitu–Revista Científica do Programa de Mestrado Profissional em Projeto, Produção e Gestão do Espaço Urbano, vol. 1, no. 2, pp. 68–86 (2015)
14. Cardoso, A.C.D., Neto, R.d.S.V.: A evolução urbana de Belém: trajetória de ambiguidades e conflitos socioambientais. Cadernos Metrópole, vol. 15, no. 29, pp. 55–75 (2013)
15. Moura, A.C.M., Freitas, C.R.: Brazilian geodesign platform: webgis and SDI and geodesign as co-creation and geo-collaboration. In: Gervasi, O. et al. (eds). Springer Nature Switzerland, pp. 332–348 (2020)
16. PNUD - Programa das Nações Unidas para o Desenvolvimento. Disponível em: <https://www.br.undp.org/content/brazil/pt/home/sustainable-development-goals.html. Acesso abril 2021
17. Becker, B.K.: Geopolítica da Amazônia. Estudos Avançados **19**(53), 71–86 (2005)