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RESEARCH ARTICLE

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MULTITEMPORAL ANALYSIS OF THE USE AND OCCUPATION OF CONTROLLED-DENSIFICATION ZONES (CDZ) IN THE CITY OF MARABÁ-PA, BRAZIL: CHALLENGES, REFLECTIONS, AND NEW DELIMITATIONS

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ABSTRACT

The city of Marabá, located in southeastern Pará, presents a division of its urban macrozone in its Municipal Master Plan that allows for the balanced distribution of population density in the city. Among the existing sectors, there are the Controlled-Densification Zones or Sectors (CDZs), which exist to distribute urban activities. In this context, the present study aimed to verify the limits of the CDZ areas in the Nova Marabá, Velha Marabá, and Cidade Nova districts, as they are designated in the territorial plan, performing a multitemporal analysis to understand the expansion dynamics of these areas in the municipality. The Historical Images tool of the Google Earth Pro software was used to analyze images from the years 2005, 2010, and 2020 and, later, image charts were generated. The results showed that some CDZs in the Velha Marabá and Nova Marabá districts should be removed in the next Master Plan revision, as they currently no longer meet the guidelines set out regarding these spaces. It was concluded that the disorderly expansion exceeded the CDZ limits delimited in the 2018 Master Plan, with the population starting to occupy areas of environmental interest and risk areas in all the analyzed districts.

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INTRODUCTION

In Brazil, it is possible to note changes caused by different growth processes in older cities, which were responsible for promoting the expansion of the urban area in the territory. In the Amazon region, Abelém (2018) highlighted that from the 1960s onwards, with the inauguration of the BR-010, also known as the Belém-Brasília Highway, and the expansion of tax incentives for agricultural projects in the region, social tensions were accentuated, fostering the race for

land in the area. As in several locations in the Amazon region, the municipality of Marabá, located in the state of Pará, also attracted a large population in the second half of the 20th century. This increase in migration was strongly influenced by the commercial dynamics installed in the city, such as the production of soy, chestnut, rubber, diamond and gold ore, and wood, among others (LOBATO; EMMI, 2014). The construction of highways, including the BR-230 (known as the Trans-Amazonian Highway), which runs through the city of Marabá, also boosted the region's transformation process, given it

was designed to integrate the Brazilian North and Northeast (SILVA, 2006). Due to its geographic position and logistical facilities, such as the transport of ore by train and agricultural products by road, the municipality ended up becoming one of the most important centers of urban development in the state of Pará (ALMEIDA, 2008). In the end, all these changes continue to alter the configuration of its territory. In this sense, zoning instruments such as Master Plans are designed in an attempt to guide these changes, aiming at controlling the use and occupation of the land. This contributes to defining limits and helps regulate the ordering of properties for future expansion in existing areas (POUBEL; CAMPOS, 2019).

Among the zones that can be delineated by a Municipal Master Plan, one of them is known as Controlled-Densification Zone (CDZ), also called Controlled-Use Zone (CARVALHO; BRAGA, 2001), which was the central topic of study in this analysis. According to Article 13, item III, of the Master Plan of Marabá, a Controlled-Use Sector corresponds to a “built environment characterized by the discontinuity of infrastructure and occupation, including existing or proposed housing and industrial areas and areas of environmental interest” (MARABÁ, 2018, p. 7). CDZs can be analyzed using GIS (Geographic Information System) toolsto ascertain the pattern of evolution of urban expansion in the urban perimeter. According to Andrade, Souza, and Gomes (2019), this multitemporal investigation consists of a study using images collected at different time intervals in which changes that may have occurred in the chosen period are observed. In this sense, the present study proposed to carry out a multitemporal analysis of the area of the CDZs disposed in the urban centers of Marabá, highlighting their reduction over the years, in order to assist in the generation of information that may perhaps be adopted in the urban strategic planning of the city.

THEORETICAL BACKGROUND

According to Rodrigues (2010), the idea of defining the term “urbanism” may depend both on the professional’s training and the researcher’s field of study, thus risking being a simple implementation of infrastructure in a space or a more complex process of transformation. In line with Sposito (2004), urbanization is a long process that is denoted in the midst of distinct modes of production, appearing in different forms and that must be read together with spatiotemporal movement. Thus, it is necessary to study various segments in an urb, such as “the analysis of the order and historical evolution of cities, regarding the level of development of productive forces, to the stage of the social and territorial division of labor” (SPOSITO, 2004, p. 35). Through this perspective, Cordovil and Barbosa (2019), while analyzing the trends of expansion and dispersion of a city in an urban agglomeration in northwestern Paraná, highlighted that the current direction of cities is towards the production of an extensive urbanized territory, where peripheral and rural areas are occupied by residential, commercial, and industrial areas.

Based on these aspects, the city of Marabá, which has undergone transformations due to the action of urbanization, the action of the state, and its economic relations, reveals itself as an urban centrality in southeastern Pará and as a functional space, being, therefore, considered a city that presents demands for capitalist attenuation, but that is still trying to deal with the negative dimensions of its social reality. According to Lobato and Emmi (2014), from the second half of the 20th century onwards, new space production activities were installed in Marabá, thanks to changes in its perimeter and the advancement of migration. Projects such as the construction of BR-010, BR-230, and BR-163 (the Belém-Brasília, Trans-Amazonian, and Cuiabá-Santarém Highways, respectively), caused a significant impact on regional dynamics during this period (SILVA, 2006). In Marabá, the bridge that crosses the Itacaiúnas River, inaugurated in 1981, continued the Trans-Amazonian Highway, providing a solid incentive to migration due to the high value of land and ease of transport, since the bridge replaced the crossing of the river previously carried out by ferries (SILVA, 2006). Figure 1 shows the

moment that the population of Marabá walked on the bridge for the first time, right after its inauguration.



Source: Casa da Cultura de Marabá Foundation, 1981.

Figure 1. Population of Marabá walking on the Itacaiúnas River bridge during its inauguration in 1981

Considering the history of Marabá, and in line with Almeida (2018), urban planning should go beyond physical and territorial aspects and deal with territorial planning and its irregularities in order to achieve greater goals, such as the protection of the right to land, urban infrastructure, transport, and leisure, in addition to controlling the implications of urban growth and its negative effects, especially when it comes to the environment and preservation areas. One of the instruments that help in urban planning, without a doubt, is the existing legislation. Brazilian laws concerning urban regulations have been changed over the decades, mainly influenced by the need to organize space and preserve the environment. However, it was only after the 1988 Constitution of the Federative Republic of Brazil (FC/88) that urban-related issues began to have a more targeted and defined legal format (BONAVIDES, 2000). Following the actions of federalism, with the new constitutional text, urban policy gained a special chapter (Articles 182 and 183 of the FC/88), where several relevant instruments were created in terms of urban planning at the municipal level (BONAVIDES, 2000). These new articles of the FC/88, for example, took approximately twelve years to be implemented, and such regulation came about through Law nº 10,257 of 2001, which was called the “City Statute”. Sotto *et al.* (2019) complemented that the implementation of the City Statute aimed not only to control the use of urban property for the benefit of the sustainable use of urban space but also to regulate the guidelines of the Municipal Master Plan, as described in Article 40, §1º, of the Statute:

Art. 40. The Master Plan, approved by municipal law, is the basic instrument of urban development and expansion policies. §1º The Master Plan is an integral part of the municipal planning process, and the multi-year plan, budget directives, and the annual budget must incorporate the guidelines and priorities contained therein (BRASIL, 2001, p. 11).

As for Marabá, the first Master Plan was devised in 2006, which, after undergoing revision, was published in 2018. The mind map in Figure 2 shows the path followed within Brazilian legislation, starting with FC/88, for the implementation of urban policy from the federal to the municipal level.

It is important to emphasize that legal instruments alone are not enough to improve the quality of urban life in Brazil. Along with laws, the population’s participation and good political performance by the municipal administration are essential. Still, the Master Plan is a relevant instrument in the zoning for land use and occupation in a municipality, as it defines limits and helps guide the ordering of properties for future expansion in existing areas (POUBEL; CAMPOS, 2019).

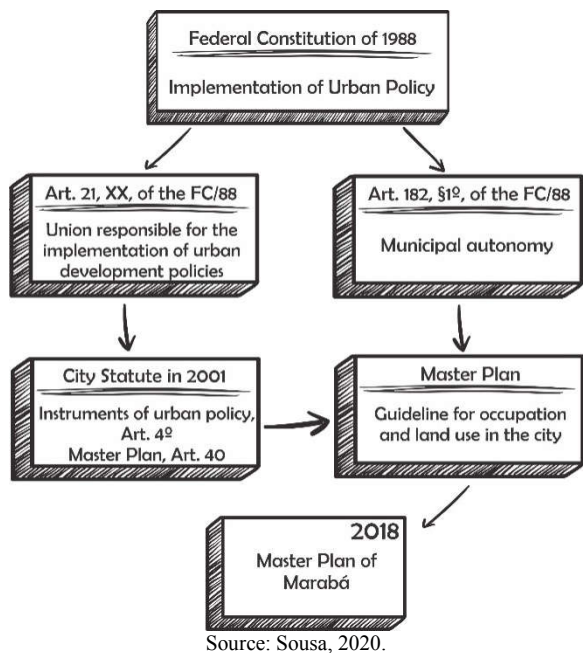


Figure 2. Mind map of the implementation of urban policy in the Brazilian legislation

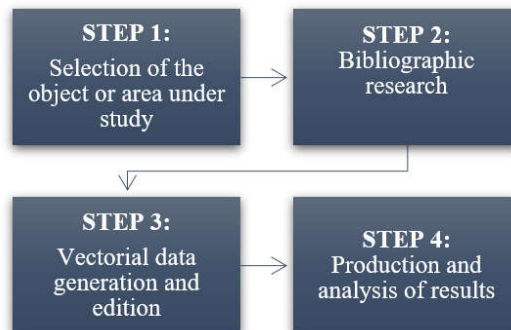
Among the zones that can be delineated by a Municipal Master Plan are the Controlled-Densification Zones (CDZs), which are also known as Controlled-Use Zones (CARVALHO; BRAGA, 2001). In this context, the Master Plan of Marabá (MPM), for example, in the division of the urban macrozone, presents different degrees of consolidation and basic infrastructure that enable the balanced distribution of population density in the city (MARABÁ, 2018). To this end, the city's Centers, Districts, and Expansion Zones were subdivided into sectors: Consolidated Sector, Consolidation Sector, Controlled-Use Sector, Recovery and Qualification Sector, and Special Perimeters (MARABÁ, 2018). Briefly, Controlled-Use Zones (CDZs) must exist at the territorial level for the better distribution of urban activities in order to reduce the pressure in the central area of the city caused by population densification (VARGINHA, 2018). This can be done by inducing residents of the area of interest to occupy "urban voids" and underutilized areas through urban policy instruments (POUBEL; CAMPOS, 2019). Regarding the Controlled-Densification Zone sector of the city's urban macrozone, the Master Plan of Marabá establishes the following guidelines for these areas:

- Promote landholding regularization when it does not conflict with environmental preservation;
- Prevent urban occupation in environmentally protected areas;
- Promote the urban qualification of areas with precarious urban standards;
- Recover environmental preservation areas degraded by urban occupation (MARABÁ, 2018, p. 10).

These areas can be analyzed using GIS tools, such as satellite images and data processing software. Also, in order to investigate the evolution of urban expansion within the perimeter, a multitemporal investigation can be carried out. This type of assessment consists of a study using images collected at different time intervals to observe changes that may have occurred during the established period (ANDRADE; SOUZA; GOMES, 2019). They can be represented through axial maps (a simplified representation of the road network and its integration) or image charts (a mosaic of aerial photographs or satellite images). The method adopted herein has been commonly used in studies to monitor the urban growth of cities due to the possibility of simulating scenarios and delimiting areas with minor or significant population development (ANDRADE; SOUZA; GOMES, 2019). Thus, multitemporal analysis showed to be an applicable method to visualize the situation of the CDZs in the city of Marabá.

METHODS

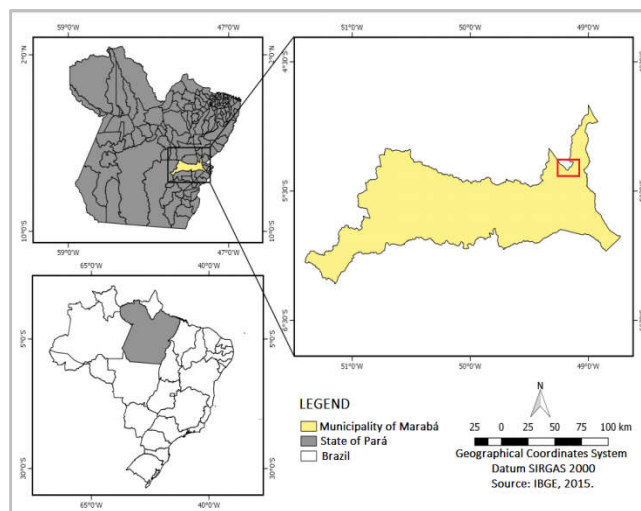
The methodological framework used in this study consisted of four stages, which are listed in Figure 3, with the contribution of an "image chart", outlined by Souza (2019). All these steps aim at organizing the data and structuring the means to be used in the final stage of characterizing the CDZs in Marabá.



Source: Sousa, 2020.

Figure 3. Steps of the methodological framework

Step 1 addresses the studied area, in this case, the municipality of Marabá, which is located in the southeast region of the state of Pará. The city is situated at a meeting point of two rivers, Tocantins and Itacaiúnas, which form a "y" shape in the middle of the city when viewed from above (ALMEIDA, 2008). With an estimated population of 283,542 inhabitants, Marabá is the fourth most populous municipality in Pará, with an extensive territorial area of 15,128.058 km², according to data from the IBGE (2020). Figure 4 shows the location of the municipality in the state of Pará, highlighting the position of the urbanized centers in the red rectangle.



Source: Sousa, 2020.

Figure 4. Location of the municipality of Marabá

As for the urban area, according to the Master Plan of Marabá, the city is divided into centers and districts, being, therefore, deemed as polynucleated. The existence of CDZs in the Velha Marabá, Nova Marabá, and Cidade Nova nuclei, indicated in Figure 5, were analyzed.

Step 2, which referred to the bibliographical research, dealt with the choice of studies on the subject. For this purpose, articles from periodicals, municipal and federal legislation, and books, among others, were selected. The objective was to find studies that provided information for the generation of new data, serving as a basis for the production or analysis of results or as a means for consultation.



Source: Sousa, 2020. Adapted from Geo Eye (Google Earth Pro) on11/20/2021.

Figure 5. Satellite image of the Velha Marabá, Nova Marabá, and Cidade Novadistricts

Meanwhile, the multitemporal analysis, derived from in Step 3, was performed by obtaining a series of images acquired by the Google Earth Pro software in its Historical Image tool. Subsequently, the CDZ polygons were manually delimited through editing using the QGIS program, version 3.4. The years in which the images were collected in the software were 2005, 2010, and 2020. The initial idea was to choose at least 5 different years for the area analysis; however, in a pre-test, some years (2009, 2012, and 2014) showed images of Marabá that presented distortions, were colorless, or exhibited cloud clusters. After extracting the images from Google Earth Pro and creating the polygons with the QGIS program, the polygon-containing images underwent refinement in the Corel Draw 2020 program to organize the layout of the final map. The image chart was elaborated to show the evolution of the increase in urban area in the city during the selected years.

Chart 1. Classes for expansion analysis

AUTHORS	CLASSES	PATTERN
Alves et al. (2008)	Residential	Verification of occupation on blocks and in individual housings.
Alves et al. (2008)	Industrial/Commercial/Institutional	Large and medium-sized buildings.
Alves et al. (2008)	Hydrography	Presence of rivers, streams, and creeks near the urban area.
Alves et al. (2008)	Preservation areas	Environmental Protection areas.
Alves et al. (2008)	Urban forestation	Streets and avenues that present vegetation.
Alves et al. (2008)	Urban voids	Unoccupied areas subject to construction.

Source: Adapted from Alves et al. (2008).

Table 1. Area reduction indexes

INDEX	REDUCTION
R1	$X < 5\%$
R2	$5\% \leq X < 25\%$
R3	$25\% \leq X < 50\%$
R4	$50\% \leq X < 75\%$
R5	$75\% \leq X < 100\%$
R6	$X = 100\%$

Source: Sousa, 2020.

The analysis of the results, performed in Step 4, was discussed in terms of the delimitations regarding the CDZs established in the Master Plan of Marabá, the form of expansion of the urban area over the years in each district and, also, the existence of local growth trends. In addition, the characterization of the occupied area considered the relationship with the infrastructure of the constructions that were present in the area. As a basis for analyzing the results, the study conducted by Alves et al. (2008), which used “classes” to understand the dynamics of occupation in cities, taking into account

physical, natural, and architectural aspects, was considered. These classes are shown in Chart 1. In order to identify the CDZs in each district’s image chart, a code composed of letters and two numbers was generated, in which the letters represented the initials of the districts’ names. For example, the Nova Marabá center has the initials NM; therefore, these letters were used as part of the code, followed by two random numbers. The same was established for the Cidade Nova (CN) and Velha Marabá (VM) districts. In addition, each CDZ was assigned an index related to the decrease in area, as shown in Table 1. The size of each CDZ’s area in each respective year was compared to that of the previous year, resulting in a percentage of reduction, which corresponded to the value of X, shown in Table 1. Thus, if the reduction was less than or equal to 5% from 2005 to 2010, for example, the CDZ received an index R1.

RESULTS AND DISCUSSION

The discussion of this topic was based on the information contained in Image Chart 1 of the CDZs in Figure 6. According to the figure, specifically the polygonal areas, it is possible to visualize a significant reduction when comparing the images in the selected years. In 2005, the initial CDZ (VM01) corresponded to a total area of 0.341 km², occupying part of the Tocantins River waterfront of the Velha Marabá district and central spaces with small businesses and residences, limiting itself within the urban perimeter with an area of environmental interest in the municipality. The urban subdivision of VM01 into blocks can also be observed, separated by a regular road system, consisting of lawns and trees. Internal urban voids can be observed in these blocks, as well as the beginning of occupation in their external limits. Medium and large-sized industrial or institutional buildings were not found within the CDZ in the year in question. However, in 2010, the aforementioned CDZ was fragmented into three new zones: VM02, VM03, and VM04. Considering the area reduction indexes and comparing the initial CDZ with the newly formed zones, all of them can be classified as having an R5 index, i.e., they presented a reduction between 75 and 100% in size, as observed in Table 2, which shows the classification of the area reduction indicator in each delimited zone.

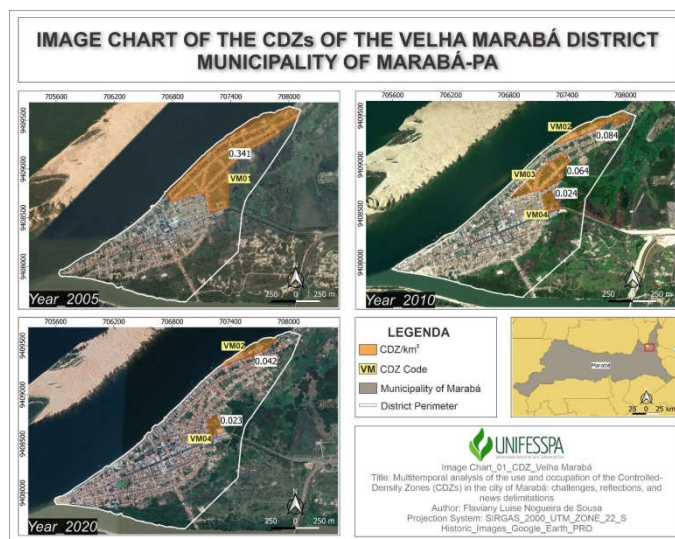


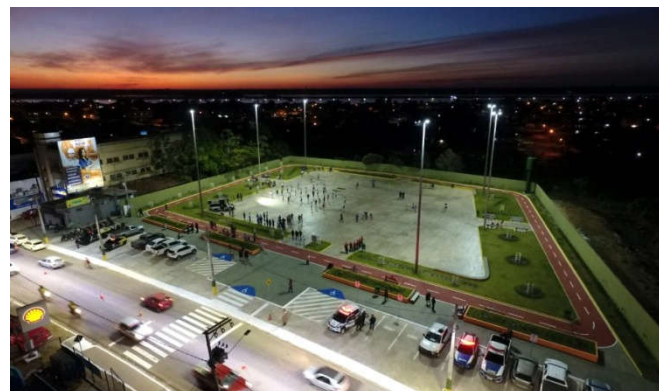
Figure 6. Image chart of the CDZ sin theVelha Marabá district

Table 1. Areas of the CDZin theVelhaMarabánuclous indicating the reduction indexes between the years 2005 and 2020

CDZ	Area km ² (2005)	Index	CDZ	Area km ² (2010)	Index	CDZ	Area km ² (2020)
VM01	0.341	R5	VM02	0.084	R3	VM02	0.042
		R5	VM03	0.064	R6	-	-
		R5	VM04	0.024	R1	VM04	0.023

Source: Sousa, 2020.

In the case of CDZ VM02, in 2010, it occupied only half of the district's waterfront area previously occupied by CDZ VM01, although its space was now filled with trees, square, and a long sidewalk for the circulation of pedestrians. CDZ VM03, in the same year, presented itself as an urban area composed of residential homes that also contained urban voids in the internal space of the block, characterizing local forestation. Likewise, CDZ VM04 shared the same features but was located closer to the main entrance of the district. Considering the year 2020, a further reduction in area can be observed in the CDZs over the past ten years. CDZ VM02, for example, now has an area of 0.042 km², being, therefore, classified as having an R3 index since, when compared to its area in 2010, there was a reduction of 25 to 50%. VM02 continued to have an area destined for walking and forestation. However, its only urban void space in 2010 is currently occupied, indicating constructive densification. Since it no longer has an area available for occupation, it can be inferred that in the next revision of the Master Plan, this CDZ will be removed from the MPM. On the other hand, CDZ VM03 ceased to exist in the plan due to its significant occupation, with the construction of residences. On account of the area reduction index of 100% (R6) in VM03, there are no more urban voids available for occupation. Between 2010 and 2020, CDZ VM04 did not undergo such a significant reduction in area, being therefore assigned an R1 index. This CDZ is not fully occupied because it has always been allocated by civil defense to people in vulnerable situations, such as during the flooding of the Tocantins River. However, in 2020, the municipal administration decided to build a sports and leisure center (Figure 7), which should be considered in the perimeter in the next revision of the CDZs in the Master Plan of Marabá.

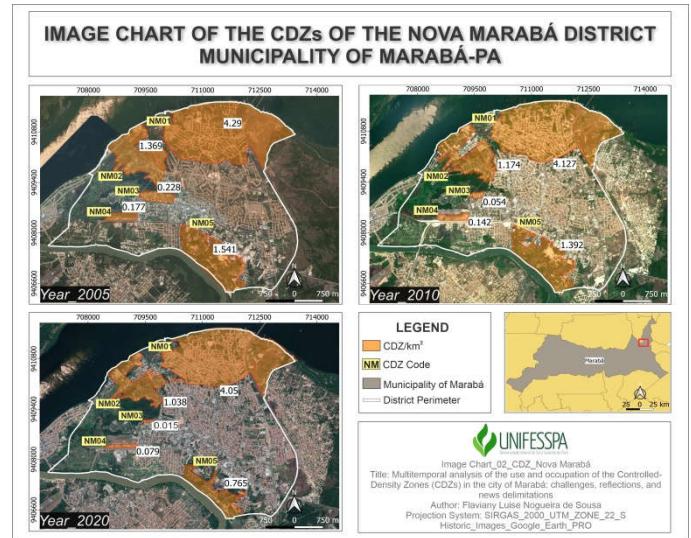


Source: City Hall of Marabá, 2020.

Figure 7. Current occupation of CDZ VM04

In general, the areas of the CDZs in the Velha Marabá district meet the definitions set out in the Master Plan, seeing that the residential use of space and streets promoted by the population itself was observed within each CDZ. However, regarding the guidelines for the sector, with the occupation of floodable areas, it is clear that the provisions of the MPM are not being met. As for the expansion pattern of Velha Marabá, it can be noted that the district was conditioned to a dispersion of residences and businesses in the center of the district perimeter, in the year 2005. In the end, these areas lack a tendency or expectation of growth within the perimeter since they no longer contain urban voids. The next Image Chart to be analyzed is the one in Figure 8, which refers to the Nova Marabá district. In general, the area reduction of the CDZs of Nova Marabá was not as expressive over the years when compared to the transformation of the previous district occupying part of the northern region of the perimeter of the Nova Marabá district, bordering on the left with the municipality's area of environmental interest. The occupied area was basically composed of residences, with small commercial centers built and dispersed throughout the neighborhoods. In 2010, this CDZ showed an R1 index reduction, i.e., a decrease in size at a proportion of less than 5%, as can be observed in Table 3. However, when comparing the images between these two years, a significant occupation of urban voids in this CDZ was noted, leaving the streets almost imperceptible. In 2020, there was again a reduction in the area of less than 5% (R1). As can be seen in the Image Chart of the

district, some green spaces within the perimeter were completely occupied. Areas close to the perimeter limit are considered susceptible to floods during flooding events of the Tocantins River, a fact that may justify their not having been fully occupied in the past 10 years.



Source: Sousa, 2020.

Figure 8. Image Chart of the CDZ of the Nova Marabá nucleus

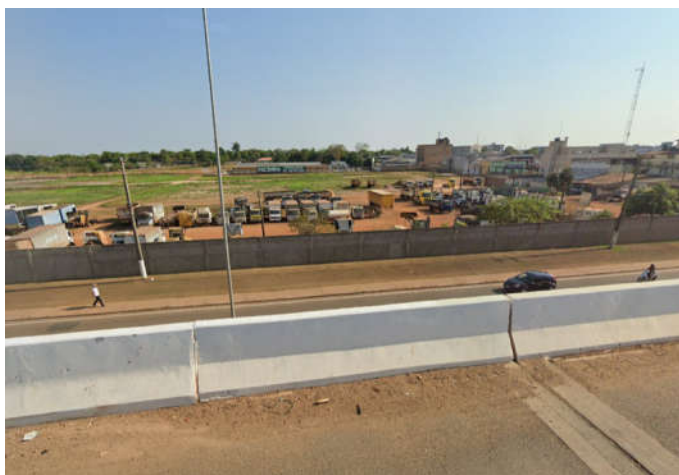
Table 3. Areas of the CDZ of the Nova Marabá nucleus indicating the reduction indexes between the years 2005 and 2020

CDZ	Area km ² (2005)	Index	CDZ	Area km ² (2010)	Index	CDZ	Area km ² (2020)
NM01	4.290	R1	NM01	4.127	R1	NM01	4.05
NM02	1.369	R2	NM02	1.174	R2	NM02	1.038
NM03	0.228	R5	NM03	0.054	R4	NM03	0.015
NM04	0.177	R2	NM04	0.142	R3	NM04	0.079
NM05	1.542	R2	NM05	1.392	R3	NM05	0.765

Source: Sousa, 2020.

As for CDZ NM02, located in the western portion of the district, around 2005, it had an area corresponding to 1.369 km², which was almost completely unoccupied, with few streets and popular housing scattered throughout the area. This may have been due to the fact that it is located between two areas of environmental interest. From 2005 to 2010 and 2010 to 2020, there was a minimum reduction (R2) in NM02. The current CDZ has an area of 1.038 km², maintaining an occupation pattern equal to that of 2005, although with changes related to horizontal expansion alone, through the installation of more residences. CDZ NM03 featured an initial marked expansion by businesses and private universities in the region. The area, which in 2005 had few urban voids, underwent significant occupation with residences, presenting a reduction of 75 to 100% (R5) in 2010. Among all CDZs of the district, VM03 was the one that exhibited the most losses in initial area. Currently, this CDZ is practically entirely occupied, leaving an area of approximately 0.015 km², indicating a reduction of 50 to 75% (R4) over the past 10 years. NM04 is a rather unique CDZ, as it is located in an area of environmental interest, subject to almost 100% flooding. In 2005, the area consisted of a vast space that was not occupied by residences or businesses. However, the presence of preserved vegetation must also have influenced its non-urbanization when compared to the other CDZs in the district. The initial area of NM04 was approximately 0.177 km², undergoing a reduction of R2 index until the year 2010, i.e., between 5 and 25%, and 10 years later, in 2020, a reduction between 25 and 50%, i.e., of R3 index.

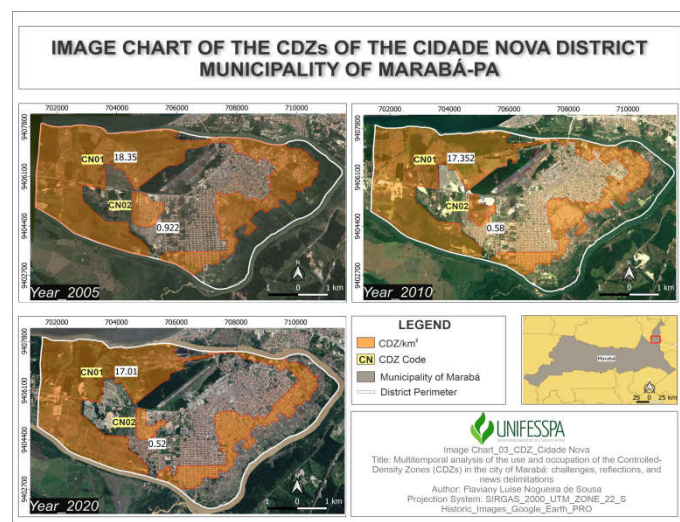
Currently, this CDZ accommodates small hardware stores, a space for goods transport vehicles (Figure 9), and a gas station. Since there are no urban voids available, it is possible that this area will be removed from the CDZ map after the revision for the city's new Master Plan.



Source: Image from Google Street View on 12/05/2020.

Figure 9. Occupied area in CDZ NM04 (2020)

Lastly, CDZ NM05, located in the southern region of the Nova Marabá district, had an area of 1.541 km² in 2005, with practically no signs of residential, commercial, or street occupation. At that time, vegetation was very present in this area. After 5 years, in 2010, this CDZ presented a reduction of R2 index in its area, *i.e.*, between 5 and 25%, and began to be occupied by small food and ceramics distributors. From 2010 to 2020, this CDZ lost around 25 to 50% (R3) of its area in relation to the previous perimeter.



Source: Sousa, 2020.

Figure 10. Image Chart of the CDZs in the Cidade Nova district

Table 4. Areas of the CDZs of the Cidade Nova district indicating the reduction indexes between the years 2005 and 2020

CDZ	Area km ² (2005)	Index	CDZ	Area km ² (2010)	Index	CDZ	Area km ² (2020)
CN01	18.35	R2	CN01	17.352	R1	NM01	17.01
CN02	0.922	R3	CN02	0.58	R3	NM02	0.52

Source: Sousa, 2020.

Currently, the area is occupied by few residences. Because it is located in an area susceptible to floods caused by the flooding of the Itacaiúnas River, the CDZ's current area should not be included in the Master Plan map since it poses risks to those who may occupy it in the future. Overall, according to the designations for the CDZs of Nova Marabá, it can be stated that they meet the definitions set out in the Master Plan, as they presented little infrastructure and occupation. However, regarding compliance with the guidelines, there was an advancement in constructions in floodable areas, demonstrating that there is no urban or land regularization of the existing settlements in

the district. Finally, the only CDZ in the district that has a tendency or expectation of growth within the perimeter in question is NM01. The area does not have flooding sites in its centrality, which is favorable as it does not characterize a preservation zone, allowing its occupation. The discussion regarding the CDZs in the Cidade Nova district will be based on Image Chart 03 in Figure 10. In general, and comparing the image charts of the three studied districts, the CDZs of this district were the ones that exhibited the lowest percentage of area reduction. This district has only two CDZs, which are: CN01 and CN02. In 2005, CDZ CN01 extended along the perimeter, occupying an area of 18.350 km². Among all the mentioned districts, this was the largest CDZ delimitation within the municipality in that year. Its area in the urban agglomeration was composed of vast urban voids along the perimeter of the district, lying between an area of consolidation of Cidade Nova and a special area of environmental interest, followed by the Itacaiúnas River. After five years, CN01 underwent an R2 area reduction, *i.e.*, between 5 and 25% (Table 4), due to the expansion at the extremities in the urban agglomeration of the district. These peripheral spaces were not part of any planned neighborhood; thus, the new residents lived in less satisfactory conditions in relation to public services than the occupants of the central strip.

In 2020, ten years later, the occupation rate passed both the limits of the CDZs in question and those defined for the area of environmental interest, becoming even more irregular. Its area was now 17.010 km², indicating a lower reduction index than in previous years (R1, less than 5%). Within the urban agglomeration, the current area has few urban voids to be filled. Nonetheless, on the west side of the district, the occupation by the construction of upper-middle-class condominiums and the installation of simple residences scattered within the perimeter can be observed. CDZ CN02 is located within the district of Cidade Nova, between mixed-use regions and consolidated areas. In 2005, its area measured 0.922 km², with few established and dispersed streets, basically featuring the installation of residences. The region features many urban voids, as shown in Figure 11.



Source: Image from Google Street View on 12/05/2020.

Figure 11. Areas of urban voids in CDZ CN02 (2020)

From 2005 to 2010, this CDZ underwent an area reduction, classified with an R3 index, *i.e.*, it exhibited a decrease varying between 25 and 50%. After ten years, in 2020, the area was almost entirely occupied, featuring the presence of trees, narrow streets, and explicit population densification within that zone. The area reduction between 2010 and 2020 was minimal, being classified as R2 (between 5 and 25%). In general, according to the designations for the areas of the Controlled-Use Sector in Cidade Nova, it can be stated that the CDZs of the district in question meet the definitions set out in the city's Master Plan, as they are located in areas subject to urbanization outside the flood risk quota for this district, therefore being considered actual Controlled-Use Zones. However, regarding compliance with the guidelines for the sector, advances of construction sites can be observed in the area of environmental interest, which should be preserved, demonstrating that, in the end, there is no urban or land regularization for the existing settlements in the district. Finally, the only CDZ in the district that has a tendency or expectation of growth within the perimeter in question is CN01, in its entire northern and

western sides. The area does not have flooding sites in its centrality, which is a favorable point, enabling its occupation by the population and the installation of new businesses.

CONCLUSION

Due to the aspects presented after the observations in the constructed maps, it can be concluded that Marabá has undergone changes arising from the urbanization process, which has caused the expansion of the urban area in the city's districts, altering and exceeding the limits of the Controlled-Densification Zones. According to our findings, the disorderly expansion has exceeded the limits of the CDZs delimited in the 2018 Master Plan, with the population even starting to occupy areas of environmental interest, which should be preserved. Most of these areas are close to the Tocantins and Itacaiúnas Rivers, considered risk areas due to flooding; nevertheless, it was observed that the expansion has been increasingly closer to the banks of the two rivers. The constructions within the perimeters are summarized in the mass of residential homes and small businesses, with the presence of narrow streets and trees, which appear sporadically. As for the definition of the CDZs, considering the information regarding their respective districts, almost all meet the pre-established concept. It is recommended that only some areas of Velha Marabá and Nova Marabá be removed in the next revision of the Master Plan, as they do not fit the objectives for which they were created. It was also noticed that several of the CDZs do not have any urban voids available to promote regularization or expansion within the district. Therefore, they are unable to meet the Plan's guidelines. Furthermore, as observed in the growth trends, only some CDZs in the Cidade Nova and Nova Marabá districts can meet the demand for the installation of residences or new businesses since they still have extensive safe areas, outside the flooding zones. Finally, it is expected that this study has generated sufficient informational support to assist municipal departments in the next revision of the Master Plan of Marabá, bringing new data to allow a more precise delimitation of the current Controlled-Densification Zones, and, thus, contribute to land and urban regularization in the municipality.

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