

Urban expansion, subnormal agglomerations and provision of sanitation services: a case study of the Metropolitan Region of Belém

Caio Cezar Ferreira de Souza

Phd student, UNAMA, Brazil
caiocfdesouza@gmail.com

Joyce dos Santos Saraiva

Phd student, UNAMA, Brazil
Joyce.saraivaa@gmail.com

Maria Lúcia Bahia Lopes

Phd Professor, UNAMA, Brazil
malubahialopes7@gmail.com

Abstract

The process of urban growth in Brazil remains accelerated and presents a wide variety of realities. In this article, we aim to analyze the urban expansion in the Metropolitan Region of Belém (RMB), verifying whether it occurred intensively or extensively, and whether this expansion was accompanied by an increase in subnormal agglomerations and the provision of sanitation services. The methodology was based on the elaboration of land use and occupation maps in the urban area of the RMB and on obtaining data referring to subnormal agglomerations and the scope of basic sanitation services, made available by the Brazilian Institute of Geography and Statistics. The results showed that the RMB had more extensive urban expansion in the 1990s, with a smaller expansion between 1999 and 2017. However, the coverage of basic sanitation services did not follow this expansion process and in the spaces inserted by the expansion process subnormal clusters were concentrated.

KEY WORDS: Urban territorial growth. Urban planning. Favelization. Basic sanitation.

1 INTRODUCTION

Brazilian cities are experiencing rapid growth, which, combined with low public investment in urban and community equipment, has resulted, among other things, in precarious infrastructure, unsatisfactory housing conditions, in addition to low social indicators. This process, especially in peripheral areas, contributes to the segmentation of the urban fabric and directly influences the living conditions of the population (TESSARI, 2013).

The urban fabric is formed by the accommodation of three structures: the road network, land subdivisions and buildings. The relationship between streets, lots, buildings and public spaces is the reason for the existence of the urban fabric (PANERAI, 2006).

According to the Food for the cities of the Food and Agriculture Organization (FAO) (2008), the world's urban population has surpassed the rural population in number. And by 2030, more than sixty percent of the world's population is expected to live in the urban sector. This dynamism resulting from the process of urban growth is associated with food insecurity and the growth of poverty.

In developed countries, urban expansion originates from economic growth combined with territorial overflow, but in developing countries the origin of this process occurs in different ways, and in many cases in the opposite way, with the growth of poverty that leads to land appropriations and illegal constructions on the edges of cities (BUENO-SUÁREZ; COQ-HUELVA, 2020).

The process of urban expansion has been continuous and complex, being carried out mainly along roads and towards the periphery without proper planning, thus causing several challenges for society, such as inadequate infrastructure, mobility problems and improper land use and understanding. of the factors that drive it is fundamental to propose patterns of sustainable development in the long term (AKMAL et al., 2022).

The urban expansion process can be simplified as urban territorial growth and can occur in two ways, intensive and extensive, the first being characterized by the intensification of land use and occupation and the second as the expansion of the urban fabric (JAPIASSÚ; LINS, 2014) .

In Latin America, where urban expansion has caused food insecurity in cities and their outskirts, especially where there are population sectors that are victims of poverty and extreme poverty, urban population swelling is also due to the process of migration of people attracted from regions shaken by environmental, political, employment factors, among others, in search of better living conditions in urban centers (REBELLO et al, 2017).

In Brazil, areas known as slums or invasions are the Subnormal Agglomerations, defined as irregular occupation of someone else's property for use as housing in urban areas characterized by the lack of essential public services, such as basic sanitation, and location in areas with restrictions on occupation (IBGE, 2020).

The Metropolitan Region of Belém (RMB) is also undergoing a favelization process. Inadequate or absent public planning ends up leading to spontaneous occupation and a high housing deficit, compromising human dignity. Thus, the objective of the article is to analyze the urban expansion in the Metropolitan Region of Belém, verifying if it occurred in an extensive or intensive way, and if this expansion was accompanied by the increase of subnormal agglomerations and the provision of sanitation services.

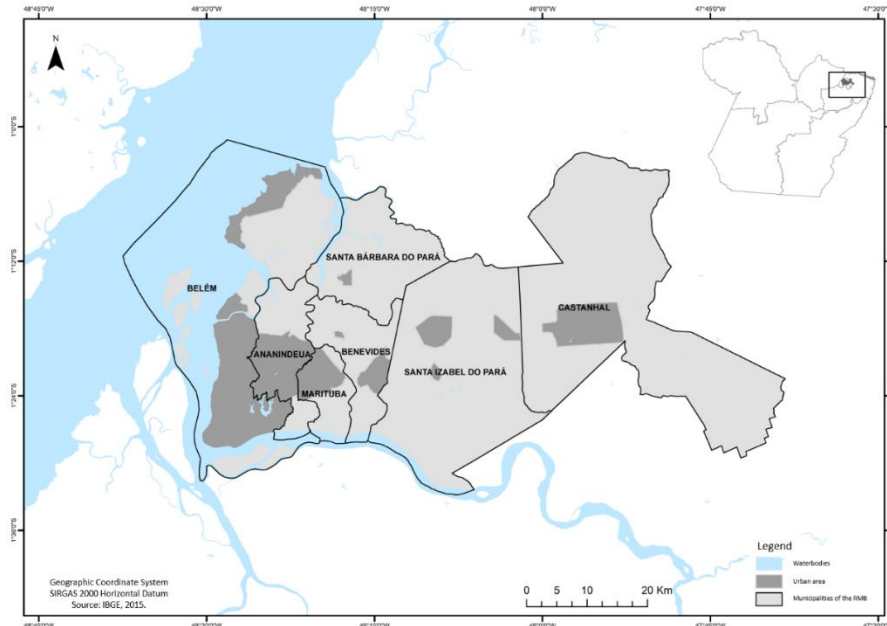
2 MATERIAL AND METHODS

2.1 Study area

The Metropolitan Region of Belém (RMB) is located in the State of Pará, northern Brazil (Figure 1), and was established in the 1970s, initially comprising the municipalities of Belém and Ananindeua. It is currently composed of seven municipalities, namely: Belém, Ananindeua, Marituba, Benevides, Santa Bárbara do Pará, Santa Isabel do Pará and Castanhal.

The urban area of the RMB was defined by the classification of the census sectors of the IBGE of the 2010 Census. The IBGE is based on the legal definitions of each municipality to define urban and rural areas (PERA; BUENO, 2016).

Figure 1 – Location map of the Metropolitan Region of Belém.



Source: Own authorship.

This region has 2,275,032 inhabitants, almost a third of the population of the state of Pará, spread over 3,565.8 km², which represents less than 1% of the state's territorial extension (1,247,954.32 km²) (IBGE, 2010). The region's GDP is R\$ 24,739,338 thousand for the year 2010, and corresponds to 40% of the state's services GDP this year, a low value when compared to the

city of São Paulo, for example, with the capital paraense, Belém, accounts for 72.7% of this total (IBGE, 2010).

According to IBGE (2010), the municipality of Belém has the highest concentration of households in the RMB, with approximately 1,393,399 inhabitants, followed by Ananindeua and Castanhal with 471,980 and 108,246 inhabitants, respectively.

Among the Brazilian metropolitan regions, the RMB has the highest incidence of households in subnormal agglomerations, with 52.5% of all households (IBGE, 2010), that is, households are located in areas considered precarious, in a situation of slums.

2.2 Land use and land cover analysis

The preparation of occupancy maps of the urban area of the Metropolitan Region of Belém was divided into seven stages. Initially, free satellite images were collected, LANDSAT 5 and LANDSAT 8, spatial resolution of 30 m, on the portal of the United States Geological Survey (USGS), identifying the scene that covered the Metropolitan Region of Belém, orbit 223 and point 61, being selected the images from the years 1989, 1999 and 2008 from the LANDSAT 5 satellite and from 2017 from the LANDSAT 8, because they present the lowest cloud cover and consequently the highest clarity in the period available for download (1984 to 2020).

Then, on the IBGE Maps Portal, access was made to the cartographic data of the RMB and its municipalities, in order to cut out the scenes from the satellite images, that is, only for the study area. The third stage consisted of the radiometric conversion of the LANDSAT 8 image, which has a radiometric resolution of 16 bits, to 8 bits, the same resolution as the LANDSAT 5 images. through the combination of the Short Wave InfraRed – SWIR 2, Short Wave InfraRed – SWIR 1 and Red bands, false color used to assess urbanization, following the guidance of Santos et al. (2014), and later the scenes were projected for the DATUM SIRGAS 2000, in the Universal Transverse Mercator Projection System (UTM), Zone 23 South.

The sixth step was the image classification process, which was subdivided into two phases. In the first one, the Iso Cluster algorithm was used, with the objective of creating a signature file to be used in the unsupervised classification. In the second, with the application of the maximum likelihood method, scenes with different classes of land use and occupation (Water Course, Vegetation and Anthropized Area) were generated through the signature file created in the previous step. And, finally, by vectorizing the images resulting from the unsupervised classification process, the areas of urban occupation in the four years analyzed were calculated.

2.3 Population growth and spatial data from subnormal clusters and basic sanitation

The identification of population growth rates and spatial coverage of basic sanitation services (water supply, sewage and garbage collection) in the urban areas of the seven municipalities of the RMB were obtained through data from the Demographic Censuses of 1991, 2000 and 2010 by IBGE, with data being collected by census tracts.

Regarding the spatiality of subnormal clusters, data were collected in the 2010 Demographic Census and in a survey carried out by the IBGE called Subnormal Clusters 2019: Preliminary classification and health information for coping with COVID-19.

Data on land use and occupation, population growth, coverage of basic sanitation services and spatiality of subnormal clusters showed different periods due to the unavailability of clear satellite images favorable for classifying land use and occupation in the same years of the Population Censuses carried out by IBGE and in relation to subnormal clusters, all available data were used. However, as the analyzed years are very close, it is possible to portray the situation of the RMB in the 1990s, 2000s and 2010s.

3 RESULTS AND DISCUSSION

In recent decades, the Metropolitan Region of Belém, according to data from the IBGE Demographic Census, has suffered a population swelling, as shown in Table 1. with regard to participation in the total population, for adjacent municipalities, such as Ananindeua, which, in 1991, accounted for about 7% of the population of the RMB, and increased in 2010 to 21.5%.

Table 1 – Resident population in the municipalities of the Metropolitan Region of Belém in the years 1991, 2000 and 2010.

County	1991	% RMB	2000	% RMB	2010	% RMB
Ananindeua	74.051	7,06	392.627	20,57	470.819	21,50
Belém	849.187	81,02	1.272.354	66,65	1.381.475	63,08
Benevides	8.361	0,80	20.912	1,10	28.912	1,32
Castanhal	92.852	8,86	121.249	6,35	153.378	7,00
Marituba	-	-	64.884	3,40	107.123	4,89
Santa Bárbara do Pará	-	-	4.009	0,21	5.458	0,25
Santa Izabel do Pará	23.728	2,26	33.078	1,73	43.000	1,96
Metropolitan Region of Belém	1.048.179	-	1.909.113	-	2.190.165	-

Source: Own elaboration with IBGE (1991; 2000; 2010).

In terms of urban expansion, it is observed in Table 2 that the Metropolitan Region of Belém, as a whole, had an extensive territory of expansion of the anthropized area, between the years 1989 and 1999, with an increase of 25.65% in the urban space, with the increase in population being a determining factor for the expansion of this territory, since between 1991 and 2000 it grew by 82.14%. Rego et al. (2013) state that population growth is accompanied by the increase in urban agglomerations.

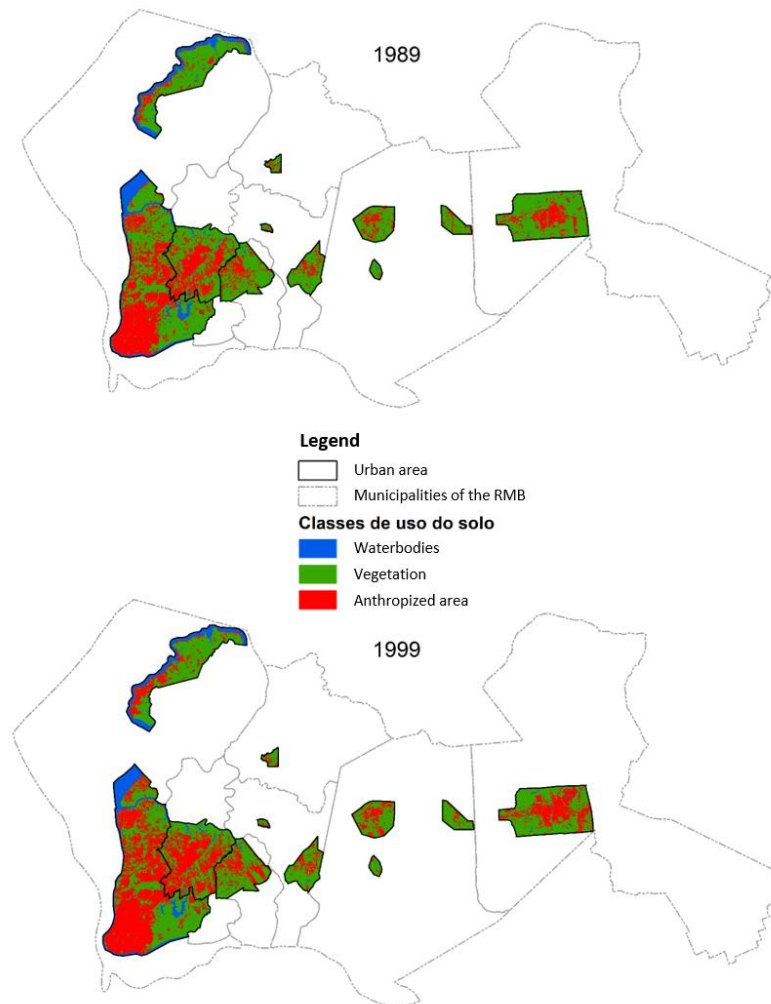
Table 2 – Growth rates of anthropized area and urban population in the municipalities of the Metropolitan Region of Belém.

County	Area			Population	
	1989-1999	1999-2008	2008-2017	1991-2000	2000-2010
Ananindeua	21,18%	9,60%	4,25%	430,21%	19,92%
Belém	22,42%	2,89%	-0,36%	49,83%	8,58%
Benevides	7,18%	13,19%	6,24%	150,11%	38,26%
Castanhal	56,13%	21,06%	9,55%	30,58%	26,50%
Marituba	36,50%	20,31%	2,85%	-	65,10%
Santa Bárbara do Pará	-6,78%	41,50%	35,28%	-	36,14%
Santa Isabel do Pará	19,21%	0,08%	5,28%	39,40%	30,00%
Metropolitan Region of Belém	25,65%	7,87%	2,77%	82,14%	14,72%

Source: Own elaboration with IBGE (1991; 2000; 2010).

In the Metropolitan Region of Belém, urban expansion behaved in different ways between 1989 and 2017, as can be seen in Figure 2.

Figure 2 – Occupation of the urban area of the Metropolitan Region of Belém in 1989 and 1999.



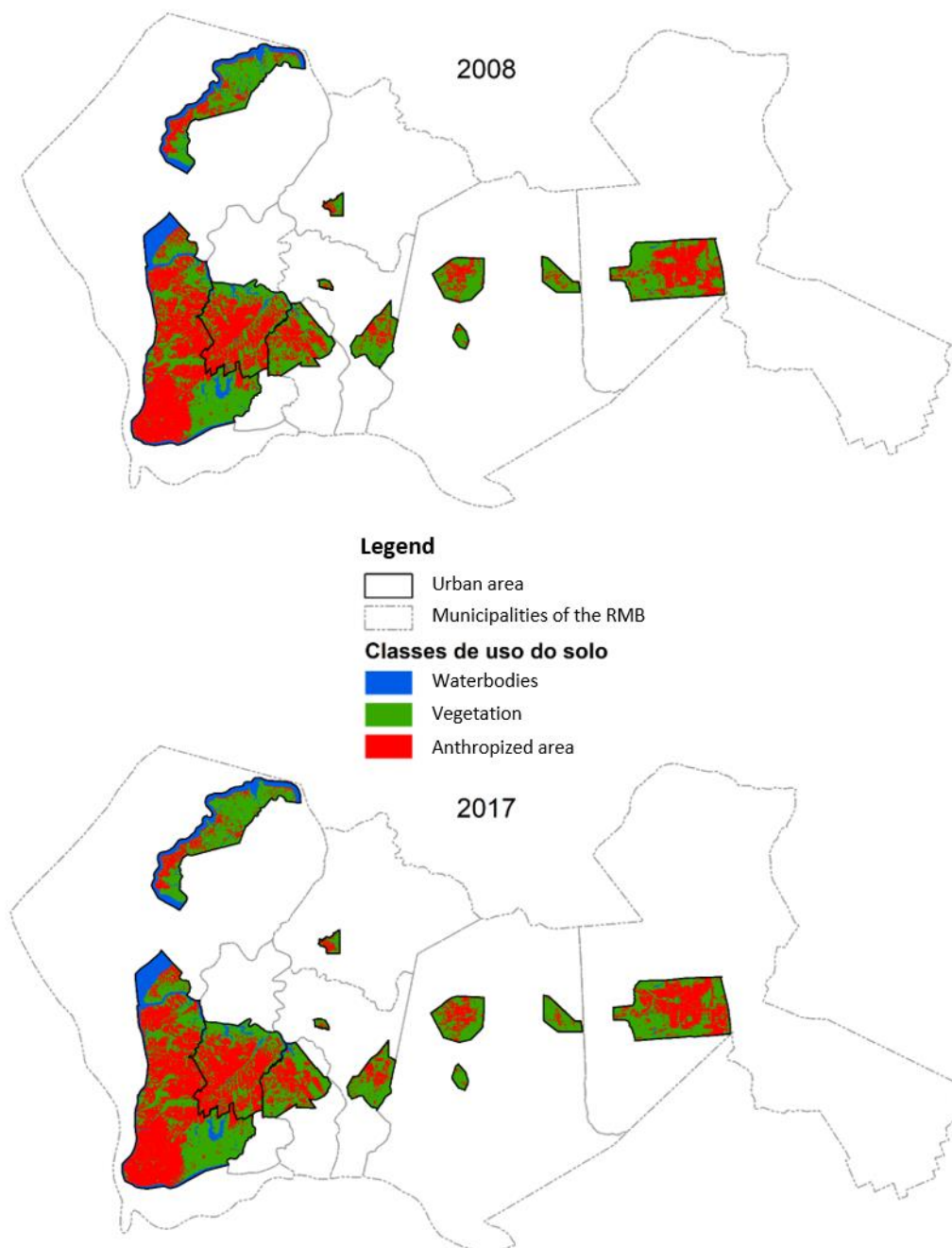
Source: Own authorship.

In 1989, it is possible to observe a predominant occupation in the municipality of Belém and in the central areas of the other municipalities, with emphasis on the municipality of Ananindeua, which was considered a “dormitory city”, due to housing the lower income population that worked in the central area. of Belém (AMARAL; RIBEIRO, 2016). Low-income residents, in addition to occupying the neighboring cities, were predominantly located in the flooded areas of the capital, which, despite being considered unsuitable for housing, were an alternative to locating close to the central region (PIMENTEL et al., 2012).

In 1999, there was an advance in extensive urban expansion in two road axes, on Avenida Augusto Montenegro and on the BR-316 highway, with an increase in the anthropized area of more than 20%, both in the municipalities of Belém and Ananindeua. Trindade Jr. (1998) points out that the metropolitan urban space of Belém, in the 1990s, was marked by a disorderly urban-real estate expansion in these aforementioned axes. In the 1990s, also with the expansion of Marituba, there was an intensification of the conurbation area between Belém, Ananindeua and Marituba, or also called by Ribeiro (2018) the metropolitan space, a denser and more modern area, with greater strength in the middle technical-scientific-informational. The conurbation process is classified as an urban phenomenon that occurs in large urban agglomerations, where the metropolis expands over neighboring cities (SANTOS; PEIXINHO, 2015).

In this phase, it is also important to highlight the urban expansion in the municipality of Castanhal, which had an increase of 56.13% in its urban area, presenting a very extensive characteristic, since between 1991 and 2000 the population of the city grew 30.58 %, so there was an expansion of the urban fabric proportionally greater than the population. This city is classified by Ribeiro (2018) as a medium-sized city, with a dense and modern urban space, but because it is farther from the metropolis Belém, it is cited as a center of regional expression, which has its insertion, along with the municipalities of Santa Bárbara do Pará and Santa Isabel do Pará, questionable, in the composition of the Metropolitan Region of Belém.

Figure 3 – Occupation of the urban area of the Metropolitan Region of Belém in the years 2008 and 2017.



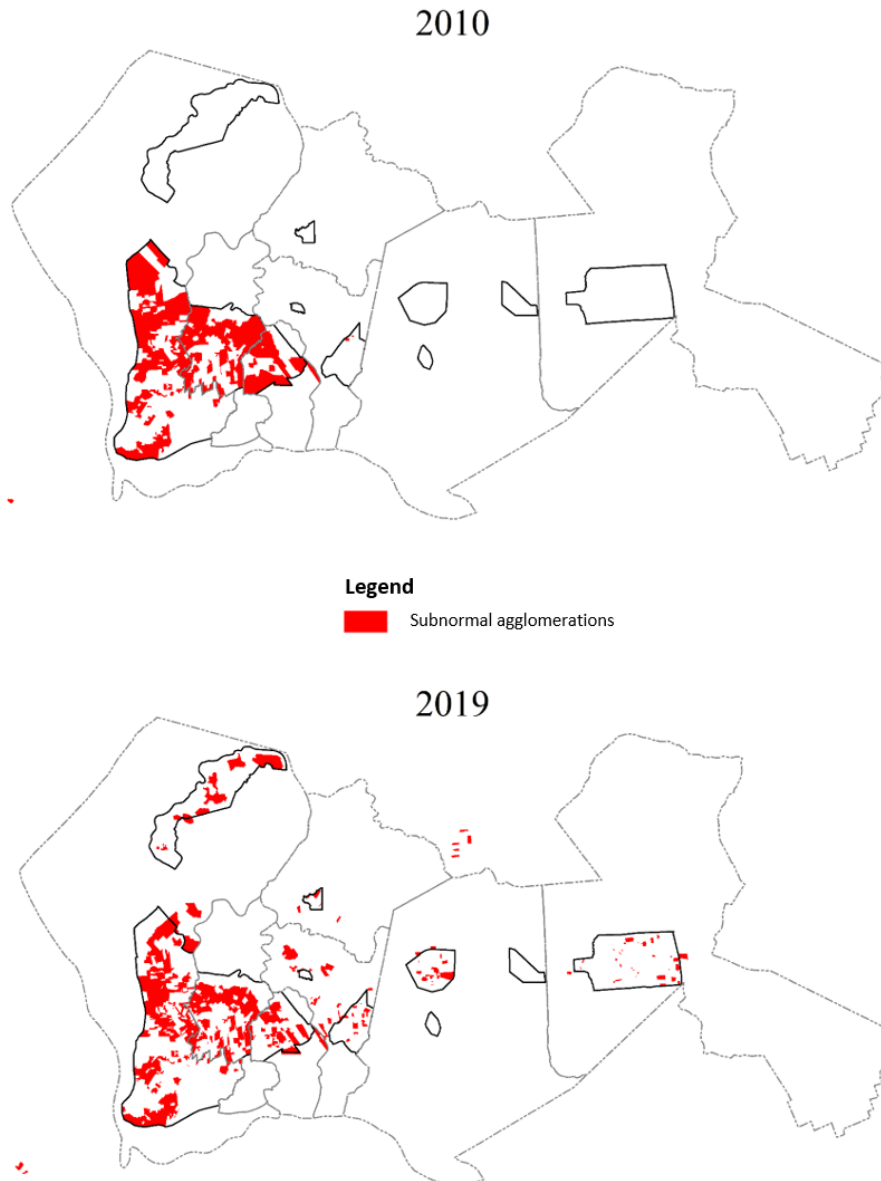
Source: Own authorship.

In 2008, with the stabilization of expansion in Belém and Ananindeua, the municipalities of Marituba and Castanhal were mainly responsible for the urban expansion of the RMB. This process is a consequence of the lack of spaces in the capital and in the neighboring municipality (Ananindeua) and of real estate speculation that makes the occupation of possible urban voids in central areas inaccessible by the neediest populations, thus boosting the process of expansion to other municipalities.

This intense process of urban expansion, especially extensive, has caused another phenomenon of large cities, slums. Figure 4 shows that the areas where the advance of urban expansion predominated are mostly occupied by inadequate housing, the subnormal

agglomerations. In 2010, these irregular occupations, according to the IBGE, were concentrated in the conurbation of Belém, Ananindeua and Marituba, especially in the low-lying areas and in the surroundings of the two road axes of urban expansion, Avenida Augusto Montenegro and Rodovia BR-316. However, in 2019, the occurrence of subnormal clusters spread to other municipalities in the RMB, including in areas considered rural. Thus, Fernandes (2012), states that the process of suburbanization of poverty, with the intense occupation of precarious settlements, is still very recurrent in the Metropolitan Region of Belém.

Figure 4 – Subnormal clusters in the Metropolitan Region of Belém in the years 2010 and 2019.



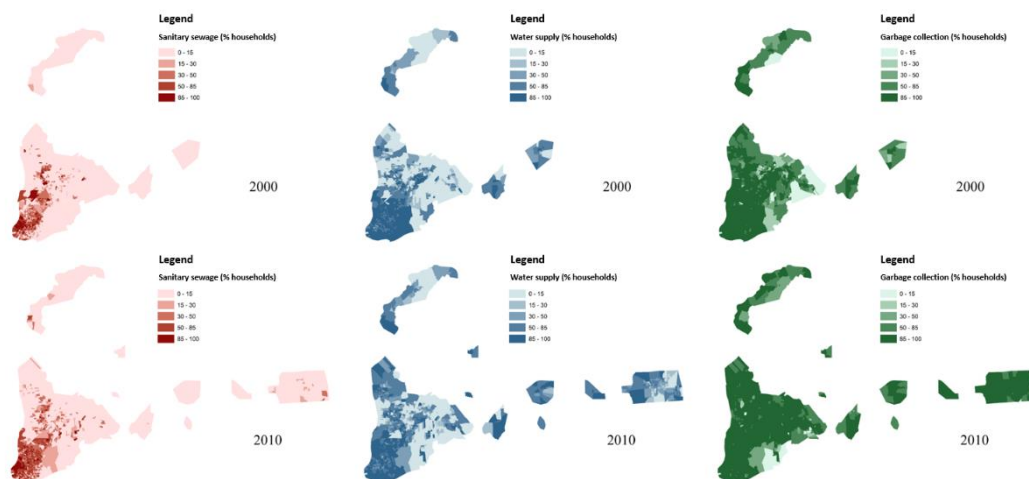
Source: Own elaboration with IBGE (2010;2019).

This occupation model has a direct impact on urban services. Susuki H. (2010) points out that the inhabitants of the favelas suffer from the absence of the most basic human needs, such as adequate housing, basic sanitation, paving and public lighting. The public administration, in turn, finds it difficult to control these territories, thus causing a continuous precariousness of

the urban infrastructure, with consequences in the socio-environmental scope, such as pollution and the increase of urban violence (LEITE, 2012).

In the case of the RMB, the high incidence of irregular occupations, especially in areas of urban dispersion, reflects low levels of basic sanitation, with emphasis on insufficient coverage of water supply in a large part of the municipality of Ananindeua and of sanitary sewage, which, as can be seen in Figure 4, it presents satisfactory rates only in the central region of Belém. IPEA (2015) states that the RMB is the Brazilian metropolitan region with the most precarious housing and urban infrastructure services, where only garbage collection and electricity supply serve approximately 100% of households, however, in the case of solid waste if you have few treatment initiatives, most of which are discarded inappropriately.

Figure 4 – Space-time dynamics of coverage of basic sanitation services in the years 2000 and 2010 in the urban area of the Metropolitan Region of Belém.



Source: Own elaboration with IBGE (2000; 2010).

The extensive expansion of the urban area, according to Leite (2012), is a fundamental factor for the unsustainability of cities, since “sustainable cities” must be more compact, having as a response to population growth the increase in urban density in return for the increase in urban density. territory expansion. Thus, the author points out that in compact areas there is a reduction in investments and costs in the services mentioned above as the most deficient in the Metropolitan Region of Belém, water supply and sewage collection..

4 FINAL CONSIDERATIONS

The results showed that the Metropolitan Region of Belém had an urban territorial growth with very extensive characteristics between the years 1989 and 1999, with an increase of 25.65% in the anthropic area, driven by a population growth of 82.14% among the years 1991 and 2000, especially in the two cities with the largest number of residents, Belém and Ananindeua. Among the more distant municipalities, Castanhal presented the greatest urban expansion, mainly in the period from 1989 to 1999, becoming an important regional center, with less intense connection with the metropolis Belém.

In a second moment, between 1999 and 2008, the municipality of Marituba experienced great growth, consolidating the conurbation of Belém, Ananindeua and Marituba, but with a

large concentration of irregular occupations and a deficit of basic services for the population, such as basic sanitation. . Thus, it is clear that the Metropolitan Region of Belém did not grow with due urban territorial planning and currently has a precarious urban infrastructure, directly affecting the quality of life of its population.

And, when analyzing the most recent urban expansion, between the years 2008 and 2017, it is possible to perceive the consolidation of the expansion in Belém, Ananindeua and Marituba, with the municipality of Benevides the probable space for a future expansion of the anthropized area of the RMB.

BIBLIOGRAPHIC REFERENCES

AKMAL, F.; KHAN, S. U.; LUQMAN, M.; AHMAD, S. R. Urban Sprawl Susceptibility Analysis of Sialkot City by Using Multicriteria Evaluation and Analytical Hierarchy Process. **Journal of Urban Planning and Development**, v. 148, n. 2, 2022.

AMARAL, M. D. B.; RIBEIRO, W. O. Castanhal (PA): entre a dinâmica metropolitana e a centralidade sub-regional de uma cidade média. **PRACS: Revista Eletrônica de Humanidades do Curso de Ciências Sociais da UNIFAP**, v. 9, n. 1, p. 77-105, 2016.

BECKER, B. K. **A Urbe Amazônica: a floresta e a cidade**. Rio de Janeiro: Garamond, 2013.

BUENO-SUÁREZ, C.; COQ-HUELVA, D. Sustaining What Is Unsustainable: A Review of Urban Sprawl and Urban Socio-Environmental Policies in North America and Western Europe. **Sustainability**, v. 12, n. 11, 2020.

FAO/MDS. **A AUP na América Latina e no Caribe: uma realidade**. Publicação distribuída no 5º Fórum Urbano Mundial (Rio, 03/2010). Disponível em: <http://agriculturaurbana.org.br/textos/AUPenALC-BrochureIPES_FAO-portugues_lo>. Acesso em: 08 de dez 2020.

FOOD AND AGRICULTURE ORGANIZATION (FAO). **Food insecurity: when people must live with hunger and fear starvation**. Disponível em: <http://www.fao.org/NEWS/1999/img/SOFI99-E.PDF>. Acesso em: 09 de dez 2020.

FERNANDES, J. C. M. L. **Assentamentos precários e dispersão urbana: o caso da Região Metropolitana de Belém**. 2012. 110 f. Dissertação (Mestrado em Desenvolvimento e Meio Ambiente Urbano) – Universidade da Amazônia, Belém, 2012.

INSTITUTO BRASILEIRO DE GEOGRAFIA E ESTATÍSTICA - IBGE. **Censo 2010**. Disponível em: <<http://cidades.ibge.gov.br/xtras/perfil.php?codmun=150140>>. Acesso em: 08 de dez 2020.

INSTITUTO BRASILEIRO DE GEOGRAFIA E ESTATÍSTICA - IBGE. **IBGE Cidades**. Disponível em: <<https://cidades.ibge.gov.br/>>. Acesso em: 08 de dez 2020.

INSTITUTO BRASILEIRO DE GEOGRAFIA E ESTATÍSTICA – IBGE. **Aglomerados Subnormais 2019: Classificação preliminar e informações de saúde para o enfrentamento à COVID-19**. Rio de Janeiro: IBGE, 2020.

IPEA. **Caracterização e quadros de análise comparativa da governança metropolitana no Brasil: arranjos institucionais de gestão metropolitana (Componente 1)**: Região Metropolitana de Belém. 2015.

JAPIASSÚ, L. A. T.; LINS, R. D. B. As diferentes formas de expansão urbana. **Revista Nacional de Gerenciamento de Cidades**, v. 2, n. 13, p. 15-25, 2014.

PANERAI, P. **Análise Urbana**. Brasília: Editora Universidade de Brasília, 2006.

PERA, C. K. L.; BUENO, L. M. M. Revendo o uso de dados do IBGE para pesquisa e planejamento territorial: reflexões quanto à classificação da situação urbana e rural. **Cadernos Metrôpole**, v. 18, n. 37, p. 721-742, 2016.

PIMENTEL, M. A. S.; SANTOS, V. C.; SILVA, F. A. O.; GONÇALVES, A. C. A ocupação das várzeas na cidade de Belém: causas e consequências socioambientais. **Revista Geonorte**, v. 2, n. 4, p. 34-45, 2012.

REBELLO, F. K.; HOMMA, A. K. O. **História da colonização do Nordeste Paraense: reflexões para o futuro da Amazônia.** Belém: EDUFRA, 2017.

REGO, J. A. D. A.; NACARETE, J. P. M.; PERNA, L. N.; PINHATE, T. B. Cidades sustentáveis: lidando com a urbanização de forma ambiental, social e economicamente sustentável. **Simulação das Nações Unidas para Secundaristas**, p. 545-573, 2013.

RIBEIRO, W. O. Dispersão metropolitana e novas formas urbano-regionais: uma proposta para o reconhecimento e a delimitação da cidade-região de Belém. **Ateliê Geográfico**, Goiânia, v. 12, n. 1, p. 132-154, 2018.

SANTOS, A. R.; EUGENIO, F. C.; SOARES, V. P.; MOREIRA, M. A.; RIBEIRO, C. A. A. S.; BARROS, K. **Sensoriamento remoto no ArcGIS 10.2.2. passo a passo:** processamento de imagens orbitais. Porto Alegre: CAUFES, 2014.

SANTOS, A. E.; PEIXINHO, D. M. Processo de conurbação: elementos espaciais do fenômeno em área não metropolitana. **Estudos Geográficos: Revista Eletrônica de Geografia**, v. 13, n. 1, p. 35-52, 2015.

SUSUKI, H. **Eco2 Cities: ecological Cities as Economic Cities.** Banco Mundial, Washington, Estados Unidos, 2010.

TESSARI, L. M. Dinâmica Centro-Periferia e Estrutura Urbana no Contexto das Aglomerações Não-Metropolitanas no Interior do Estado de São Paulo: O Caso de Araraquara/Américo Brasiliense. **Jutaí, Revista Eletrônica do curso de Geografia**, n. 20, 2013.

TRINDADE JR., S. C. **A cidade dispersa: os novos espaços de assentamentos em Belém e a reestruturação metropolitana.** 1998. 394 f. Tese (Doutorado em Geografia Humana) – Departamento de Geografia, Faculdade de Filosofia, Letras e Ciências Humanas, Universidade de São Paulo, São Paulo, 1998.