

## CLIMATE CHANGE, ADAPTIVE CAPACITY AND SUSTAINABILITY: REFLECTIONS FROM THE CITIES OF BRAZILIAN SEMI-ARID REGION

*Mudanças climáticas, capacidade adaptativa e sustentabilidade: reflexões a partir das cidades da região semiárida brasileira*

*Cambio climático, capacidad adaptativa y sostenibilidad: reflexiones mediante las ciudades de la región semiárida brasileña*

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### ABSTRACT

Climate change is a major, if not the greatest, contemporary socio-environmental issue, impacting, in particular, populations and territories that are in vulnerable conditions, as is the case of those living in the semiarid region of Brazil. In this sense, the objective of this paper is to reflect on the challenges imposed by climate change in the Brazilian semiarid region, in order to analyze the paths that cities in this territory have taken in the construction and implementation of climate adaptive capacity as a sustainability strategy. For this, the methodology of this paper follows the guidelines of a qualitative approach, making use of bibliographic and documentary research, and collecting secondary data as research instruments. From the analysis and discussion of the results, it appears that facing the effects of climate change in the semiarid region of Brazil is still a great and complex challenge for the cities in this territory. Although they rely on renewable energies (wind and solar, for example) as great potentials to face local climate changes, these cities do not present climate adaptation as an urban and environmental management strategy. Thus, it can be concluded that the construction and implementation of climate adaptive capacity as an alternative to achieve a sustainable future is still far from being configured as a strategic agenda for urban and environmental management in Brazilian semiarid cities, especially in the current context in which there is a marginalization of environmental and climate issues on the federal government's agenda.

**Keywords:** 2030 Agenda; Territorial planning; Renewable energy; Climate adaptive capacity. Brazilian semiarid.

## RESUMO

As mudanças climáticas são uma grande, se não a maior, problemática socioambiental contemporânea, impactando, em especial, as populações e os territórios que estão em condição de vulnerabilidade, como é o caso daqueles que vivem na região semiárida do Brasil. Nesse sentido, objetiva-se, com este artigo, refletir sobre os desafios impostos pelas mudanças climáticas no semiárido brasileiro, de modo a analisar quais os caminhos que as cidades desse território têm adotado na construção e efetivação da capacidade adaptativa climática como estratégia de sustentabilidade. Para isso, a metodologia deste artigo segue as orientações de uma abordagem de natureza qualitativa, fazendo uso de pesquisas bibliográficas e documental, e coleta de dados secundários enquanto instrumentos de pesquisa. A partir da análise e discussão dos resultados, observa-se que enfrentar os efeitos das mudanças climáticas no semiárido do Brasil é ainda um grande e complexo desafio para as cidades desse território. Muito embora contem com as energias renováveis (eólica e solar, por exemplo) como grandes potencializadores para enfrentar as mudanças climáticas locais, essas cidades não apresentam a adaptação climática estratégia de gestão urbana e ambiental. Dessa forma, pode-se concluir que a construção e efetivação da capacidade adaptativa climática como alternativa no alcance de um futuro sustentável ainda está longe de se configurar como agenda estratégica das gestões urbanas e ambientais das cidades do semiárido brasileiro, sobretudo no atual contexto em que se vivencia uma marginalização das questões ambientais e climáticas na agenda governamental federal.

**Palavras-chave:** Agenda 2030; Ordenamento territorial; Energias renováveis; Capacidade adaptativa climática; Semiárido brasileiro.

## RESUMEN

El cambio climático es un problema socioambiental contemporáneo importante, si no el más importante, que afecta, en particular, a las poblaciones y territorios que se encuentran em condiciones vulnerables, como es el caso de los que viven en la región semiárida del Brasil. En este sentido, el objetivo de este artículo es reflexionar sobre los desafíos impuestos por el cambio climático en el semiárido brasileño, para analizar los caminos que las ciudades en este territorio han tomado en la construcción e implementación de la capacidad de adaptación climática como estrategia de sostenibilidad. Para esto, la metodología de este artículo sigue las pautas de un enfoque cualitativo, haciendo uso de las investigaciones bibliográfica y documental, y colectando datos secundarios como instrumentos de investigación. Del análisis y discusión de los resultados, se observa que enfrentar los efectos del cambio climático en la región semiárida de Brasil sigue siendo un gran y complejo desafío para las ciudades de este territorio. Aunque dependen de las energías renovables (eólica y solar, por ejemplo) como un gran potencial para enfrentar los cambios climáticos locales, estas ciudades no presentan la adaptación climática como una estrategia de gestión urbana y ambiental. Por lo tanto, se puede concluir que la construcción y la eficacia de la capacidad climática adaptativa como alternativa para lograr un futuro sostenible aún está lejos de configurarse como una agenda estratégica para la gestión urbana y ambiental en las ciudades del semiárido brasileño, especialmente en el contexto actual en el que hay una marginación de los problemas ambientales y climáticos en la agenda del gobierno federal.

**Palabras-clave:** Agenda 2030; Ordenamiento territorial; Energías renovables; Capacidad adaptativa climática; Semiárido brasileño.

## 1 INTRODUCTION

Globally, the urbanization process is originally characterized by the migration of people from rural spaces to urban areas, with changes also in economic activity, which is no longer based on agriculture to become industrial and commercial. In these terms, Harvey (2005) states that urbanization and, therefore, cities follow the logic of the capitalist market. This phenomenon did not occur simultaneously in the countries of the world, considering that the developed and industrialized countries were the first to go through this period, while the developing countries and those with late industrialization went through this process in a late, fast and disorderly way.

In developing countries, such as Brazil, this urbanization model, which characterizes contemporary cities and societies, can contribute to the most diverse and complex challenges (MADEIROS; ALFREDO; PESSOA, 2018), including environmental ones. In these countries, the consequences of the urbanization process fall mainly on the most socially vulnerable populations. Maricato (2017) points out that social inequalities and socioeconomic vulnerability affect, in particular, the poorest populations, who occupy environmentally susceptible areas.

The production of built urban space further highlights the interaction between modernization and backward development (MARICATO, 2003). The author points out that the modernizations presented and detailed in the laws of territorial organization in Brazil, such as the laws of environmental zoning and land subdivision, actually coexist with “illegal” cities, which do not comply with the rules established in their legislation.

In Brazil, for several years we have been living with environmental degradation, which can be perceived in all cities in the country in general (MARICATO, 1994). The author also points out that environmental degradation is aggravated in the context of large cities and metropolises, where high levels of atmospheric pollution and areas subject to flooding are verified. However, this scenario also affects small and medium-sized cities, with problems such as devastation of vegetation and water scarcity (MARICATO, 1994).

On the national scene, one of the major challenges in this regard has been the lack of effective management capacity of cities in the face of the impacts of climate change, an essential capacity for urban planning models from a sustainable perspective (DI GIULIO et al., 2019; TEIXEIRA; PESSOA, 2020; TEIXEIRA; PESSOA; DI GIULIO, 2020). To some extent, these models require cities to rethink their urban and environmental management models.

For the purpose of this analysis, the Brazilian semi-arid region is investigated due to its high vulnerability to the effects of climate change (MARENGO, 2008; MARENGO et al., 2011). Associated with this, there is also the high vulnerability of the populations of this territory to the risks and effects of climate change (DARELA FILHO et al., 2016). Thus, the selection of the Brazilian semiarid occurs under the justification of being an area socially and environmentally vulnerable to climate change, with social asymmetries and challenges to deal with the local problems arising from this phenomenon.

In this sense, this article aims to reflect on the challenges posed by climate change in the Brazilian semi-arid region, in order to analyze which paths the cities of this territory have adopted in building and implementing climate adaptive capacity as a sustainability strategy. Therefore, the methodology follows the guidelines of a research with a qualitative approach, using bibliographical and documental research, as well as the collection of secondary data as research instruments to reach the results.

From this perspective, to compose a fluidity in the analysis and discussion of its results, the article is structured, in addition to this introduction, in three moments. In the first, there are the materials and methods used for the development and scope of the work, with the characterization of the study area and the presentation of the research's methodological procedures. In the second, the research results are analyzed and discussed based on their subdivision into four sub-moments. And, in the third and last, the main final considerations are made on the adaptive capacity to climate change in the context of cities in the semi-arid region of Brazil as a sustainability strategy.

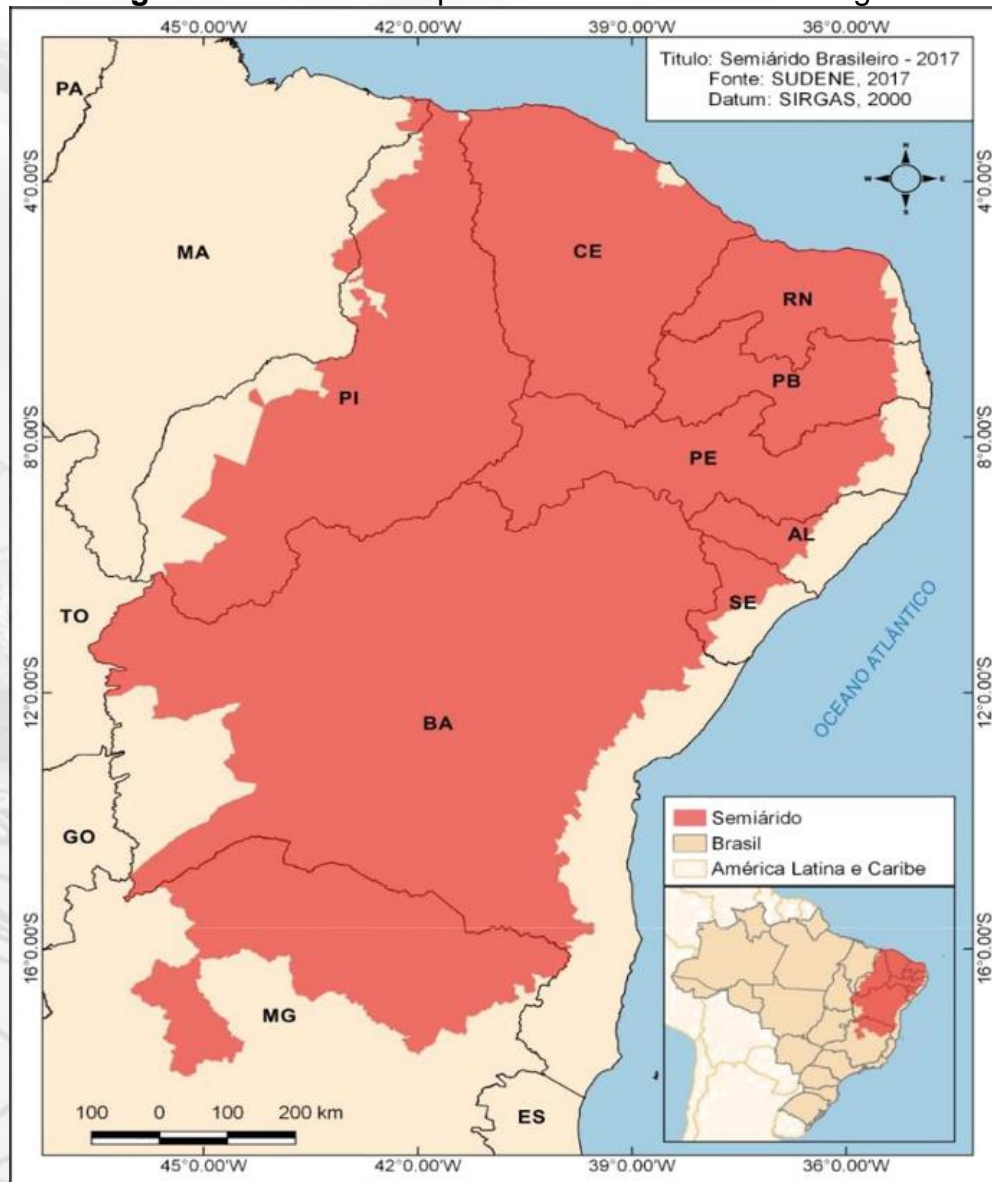
## **2 MATERIALS AND METHODS**

### **2.1 Characterization of the study area**

The Brazilian semi-arid region is considered the largest semi-arid region in the world and is delimited by the Northeast Development Superintendence (SUDENE) based on the area's climatic conditions, in particular with regard to rainfall. According to SUDENE (2017), the area corresponding to the Brazilian semi-arid region is 982,563.3 km<sup>2</sup>, extending over 1,135 Brazilian cities (20%), most of which are located in the Northeast region (89.5%) (Figure 01) and currently sheltering more than 23.8 million people from the national territory (about 12%). According to the Brazilian Institute of Geography and Statistics (IBGE, 2010),

of these approximately 12% of the total population of Brazil, 61.97% live in urban areas, while 38.03% live in rural areas.

**Figure 01** -Location map of the Brazilian semi-arid region



**Source:** Elaboration of the authors based on data from Sudene (2017).

In the region, the rainfall regime “delimits two very distinct seasons: the rainy season, lasting three to five months, and the dry season, lasting seven to nine months” (ANGELOTTI; SÁ; MELO, 2009, p. 41). The territory is also characterized by clayey, shallow and stony soils, with xerophytic vegetation (ASSIS et al., 2017), that is, vegetation adapted to aridity (in this case, from the Brazilian semi-arid region). The region is marked by intense natural climate variability, with irregular rainfall, long periods of drought and recurrent droughts,

making it a highly vulnerable area to the risks and effects of climate change (MARENGO, 2008; MARENGO et al., 2011), as presented in the fourth report of the Intergovernmental Panel on Climate Change (IPCC, 2007) by indicating that one of the effects of climate change for the region and, consequently, their populations is the reduction of water availability.

These conditions, for example, can influence the success of agricultural and livestock crops in the region and, consequently, the survival of their families (ANGELOTTI; SÁ; MELO, 2009; SILVA et al., 2010), who depend on these economic activities. Social inequality and socioeconomic vulnerability are aspects that plague the Brazilian semi-arid region, contributing to its regional environmental vulnerability. Silva et al. (2010) point out that the semi-arid region of Brazil has the worst socioeconomic indicators in the national territory. Thus, it is perceived that there is an overlap of social and environmental vulnerabilities, thus contributing to the socio-environmental vulnerability indices in the region.

## 2.2 Methodological procedures

To achieve the objective proposed in the introductory moment, qualitative research was used, under the justification, based on Deslauriers and Kérisit (2008), that this type of approach collaborates for the investigation, interpretation and analysis of urban, social and urban aspects. environmental aspects of Brazilian cities, especially in the semi-arid region, from the perspective of building urban adaptive capacity to climate change, which can be understood as the potential that public management has to promote response strategies to the effects of climate change (EAKIN; LEMOS; NELSON, 2014).

For this purpose, three data collection instruments were used. Initially, a bibliographical research was carried out through the survey of scientific publications in indexed databases such as Google Scholar about territorial planning, climate change and adaptive capacity in the context of cities in the Brazilian semi-arid region, using, for this, keywords such as “territorial planning and urbanization”, “climate changes and sustainability in the Brazilian semi-arid region” and “renewable energies and the Brazilian semi-arid region”.

The article also used documentary research based on the analysis of the National Plan for Adaptation to Climate Change (PNA), in order to observe the alignments of this

policy with the Sustainable Development Goals (SDGs) of the 2030 Agenda<sup>1</sup> In parallel, the collection of secondary data was used through the Generation Information System of the National Electric Energy Agency (ANEEL), the SIGA. The objective of this collection was to understand how Brazilian cities, particularly in the semi-arid region, have adopted and implemented wind and solar energy in their territories, in order to meet an international demand for change in the energy matrix, seeking, with this, to build a society from the perspective of sustainability.

It is from this perspective that the next topic addresses how cities in the semi-arid region are working towards the implementation and effectiveness of adaptive capacity to climate change as a sustainability strategy.

### **3 ANALYSIS AND DISCUSSION OF THE RESULTS**

#### **3.1 Territorial organization in Brazil: approaches to the urbanization process in the Brazilian Northeast**

The territory is understood in this analysis as a space of manifestations, controlled by a political group that has jurisdiction and authority to act in this space through a certain legislation (MORAES, 2005). In this perspective, this author defines territorial planning as an instrument of organization and planning of the territory that aims to organize the occupation and use of the soil, and guide the territorial and risk management that is receiving human impact.

In the context of the “Southern countries”, territorial ordering is essentially necessary due to several factors, such as “the crisis of national-developmentalism and centralized planning; [...] the trend towards flexible economies and the flexibility of places [...]” (RÜCKERT, 2005, p. 80). In Brazil, the first steps in building the National Territorial Planning Policy (PNOT) were given in 2003 (BRASIL, 2005), without more concrete actions for its completion until the current year.

However, there is a set of public policies and actions aimed at organizing the Brazilian territory, such as the 1988 Federal Constitution of Brazil (CF/88), the City Statute, the National Plan for Agrarian Reform (PNRA), the municipal master plans, municipal

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<sup>1</sup> The 2030 Agenda is a universal agenda proposed by the United Nations (UN) to promote sustainable development (UN, 2015). To this end, it defines the 17 Sustainable Development Goals (SDGs) and their 169 targets (UN, 2015).

environmental policies and Multi-Year Plans (PPAs). These policies, even though they are important strategies for the implementation and effectiveness of the territorial organization of Brazilian cities, still lack strategies such as climate adaptation measures as an alternative for building a more sustainable planet.

In the Brazilian scenario, the elaboration of the PNOT is linked to regional policies due to the country's territorial extension and the need for population and wealth deconcentration, but also with the policies of sectoral departments and macroeconomics that have effects on the territories of cities (RÜCKERT, 2007). Becker (2005) comments that territorial planning and urban and regional development policies converge in terms of social inequalities. In these terms, this author points out that territorial planning policies need to be attentive to social inequalities, economic growth, and conflicts in the occupation and use of the territory; while those of urban and regional development should focus on areas with lower income and low economic dynamism, in addition to being concerned about the issue of social inequalities.

These aspects (social inequalities, economic growth, low income, etc.) are intrinsically linked to the urbanization process that, in Brazil, began in the 18th century, with a boom between the 1940s and 1980s. Brazilian urbanization reached approximately 26%; while in 1980 it was almost 69% (SANTOS, 2005). According to the 2010 Demographic Census by IBGE (2010), the number of people living in urban areas in the country since the last decade is around 85%.

Among the five regions of Brazil, the Northeast is the least urbanized, with approximately 73% of its population living in urban areas; and the one with the largest population inhabiting rural areas, almost 27% (IBGE, 2010). The dynamics of urbanization in cities in the Northeast (and in the Brazilian semi-arid region) is even more recent compared to other Brazilian cities, beginning in the 20th century and marked by an economy integrated into the national market from the 1930s onwards (VERGOLINO; DANTAS, 2005). When compared to the other cities in the country, the urbanization process of the northeastern cities is considered much slower, being a region traditionally known as “the main expelling center of the Brazilian population” due to aspects that “range from environmental factors (droughts, desertification, etc.) to low indicators of economic development such as infant mortality, life expectancy, economic dynamism, among others” (OJIMA, 2013, p. 37).



Although configured as the Brazilian region with the lowest rate of urbanization, the Northeast seems to present new migratory and urban dynamics (OJIMA, 2013). This author also points out that “with a more urban population, even in smaller municipalities, new possibilities for attracting and, mainly, potentially retaining the population arise” (OJIMA, 2013, p. 41). It is from this perspective that one can observe in the following subtopic how the urbanization process of cities in the Brazilian semi-arid region contributes to local climate change and its urban-environmental effects, making sustainability, in this context, a central element to be analyzed.

### 3.2 Urbanization and impacts of climate change in the context of the Brazilian semi-arid region

The fourth IPCC report shows the direct relationship between urbanization and climate change as it indicates that urban areas are the most vulnerable to the impacts of climate change (IPCC, 2007). Globally, 80% of cities are located in coastal areas or close to riverbanks, which make them more vulnerable to the effects of climate change, such as rising sea levels (BULKELEY et al., 2009). The impacts of climate change in urban areas are the most diverse (Table 01).

**Table 01** -Impacts of climate change on urban areas

Climate changes	Impacts on urban areas
<b>Changes in Averages</b>	
Temperatue	Growing energy demand (heater/air conditioning); deterioration of air quality; urban heat islands
Precipitation	Increasing risk of flooding; increasing risk of landslides; migrations from rural areas; interruption of product supply networks
	food
Rising sea level	Coastal flooding; reduction of income from agriculture and tourism; salinization of water sources
<b>Changes in the extremes</b>	
Extreme rainfall/tropical cyclones	More frequent floods; higher risk of slope landslides; damage to homes, factories and urban infrastructure
	Water shortage; higher food prices;

droughts	disturbances in the hydroelectric system; migrations from rural areas
hot/cold waves	Higher energy demand in the short term (heating/air conditioning)
Abrupt climate change (still little likely, but increasingly considered)	Possible impacts of a extreme rise in sea level; possible impacts of a rapid and extreme increase of temperatures
<b>Exposure changes</b>	
population movements	Migrations from rural habitats affected
Biological changes	Increase in disease vectors

**Source:** Elaboration of the authors based on Martins and Ferreira (2011).

Climate change is known to be mainly caused by Greenhouse Gas (GHG) emissions (BRAGA, 2012), which are generally caused by human activities (75%) carried out in the urban environment (BAI et al., 2018). In this sense, Hogan (2009) points out that the urbanization process is intrinsically linked to GHG emissions and, consequently, to the phenomenon of climate change due to the growth in energy use.

The literature recognizes that the contribution of cities to the intensification of climate change is evident because they are large concentrations of gases that cause the greenhouse effect (MARTINS; FERREIRA, 2011; BULKELEY; BROTO, 2013; AYLETT, 2014; LECK; ROBERTS, 2015; RYAN, 2015). Projections by the Brazilian Panel on Climate Change (PBMC) indicate that Brazilian cities are experiencing different impacts from climate change, with the Amazon and the Brazilian Northeast being the areas potentially most affected by this global phenomenon (AMBRIZZI et al., 2007; MARENGO et al., 2009; PBMC, 2013).

The most drastic and severe effects of climate change are projected in the Brazilian semi-arid region, (IPCC, 2007). One of the impacts of climate change in this territory occurs in the Caatinga, a typical biome of the region that is highly vulnerable to climate changes due to its area being highly exploited by man (80%) (CASTRO; CAVALCANTE, 2011). Salazar, Nobre and Oyama (2007) point out that, due to high GHG emissions, the Caatinga may undergo changes in its vegetation, becoming an even more arid region with a predominance of cacti.

Another potential effect of climate change in the Brazilian semi-arid region is the intensification of long periods of drought (IPCC, 2007) which, according to Gondim et al.

(2017), are the result of factors directly linked to rainfall and land use. One of the main consequences of the increase or intensification of periods of drought in this territory is the reduction of water availability (IPCC, 2007), thus affecting the populations that inhabit it.

In the semi-arid region of Brazil, agriculture is another sector that has suffered from climate change, with consequences that can affect food security and the economy of the country as a whole (ANGELOTTI; FERNANDES JR.; SÁ, 2011). Projections point to a reduction in agricultural production, influencing the Gross Domestic Product (GDP) which depends on agribusiness (CERRI; CERRI, 2007). To face this reality, strategies are needed to mitigate GHG emissions and adapt to the effects of climate change. Some of these measures were presented in Angelotti, Fernandes Jr. and Sá (2011).

Finally, the impacts of climate change on the Brazilian semi-arid region are very diverse. Cities in this territory may be among the most vulnerable to climate change due to irregular rainfall patterns and high temperatures in the region (TORRES et al., 2012). From this perspective, social vulnerability and limitations to deal with environmental challenges are some of the local aspects of the Brazilian semi-arid region that will possibly be aggravated by climate change (GRAY; MUELLER, 2012).

In the meantime, Angelotti, Sá and Melo (2009) point out that, among all territories in Brazil, the semi-arid region is one of the most vulnerable to climate change due, in particular, to the potential impacts on the sectors of agriculture and water resources. The socioeconomic situation experienced in the Brazilian semi-arid region has always been considered a reflection of the region's natural situation, with renewable energies considered an alternative to reduce these vulnerabilities (ANHALT, 2009). This type of energy source also plays an important role in controlling climate change and, thus, in building a more sustainable society, as shown in the following subtopic.

### **3.3 Renewable energies in the Brazilian semi-arid region cities: tracing paths to combat climate change and promote sustainability**

Faced with the reality installed worldwide, in which climate change is already configured as a major, if not the biggest, socio-environmental problem to be faced by government agendas, renewable energies have been presented as an alternative to solve or at least mitigate the aggravated problems. For this global phenomenon, thus contributing to the sustainable development of societies.

In Brazil, there has been a growth in the production of renewable energies, such as wind and solar, with a forecast to increase even more in the coming years (SILVA; SILVA; PESSOA, 2019). Brazil has great potential for the development and use of renewable energies such as those mentioned, as it has great potential for installing wind farms and high solar incidence in almost all regions of the country (FREITAS et al., 2015). The conditions and natural resources that Brazil has favor its ability to expand renewable energies in its territory, which currently already configures a diversified and substantially renewable energy matrix.

Silva, Silva and Pessoa (2019) point out that the growth in the production of renewable energies in Brazil, in addition to being important in promoting sustainability as pointed out in the SDG 7, is of fundamental importance for the development of the country in view of contributing to its technology growth, its energy efficiency, and its socioeconomic development based on the generation of new forms of employment and income.

The authors indicate that, between 2016 and 2019, there was a significant increase in wind and solar energy projects in Brazil. In the case of wind, it went from 385 to 614 wind farms, representing an increase of 59.48%. Regarding solar, it went from 40 to 2,474, corresponding to a growth of 6,085%. More recently, in 2020, there has been a continuous increase in the installation of wind and solar energy projects in Brazil: the number of installed wind farms has already increased by 5.04% compared to 2019; while the growth of installed photovoltaic panels was 57.43% compared to the same year (table 01). In this sense, it can be seen that photovoltaic generation, derived from solar energy, has taken a very significant “leap” in the country.

**Table 01** -Wind and solar energy projects by states in Brazil (2020).

States	Quantity of wind farms	Quantity of Solar projects
Amapá	---	1
Amazônia	---	14
Bahia	171	31
Ceará	83	8
Espirito Santo	---	6
Maranhão	16	3
Mato Grosso	---	1
Mato Grosso do Sul	---	3
Minas Gerais	1	28
Paraíba	15	4

Paraná	1	4
Pará	---	3,708
Pernambuco	35	4
Piauí	60	20
Rio de Janeiro	1	9
Rio Grande do Norte	163	7
Rio Grande do Sul	81	11
Roraima	---	2
Santa Catarina	16	5
São Paulo	1	25
Sergipe	1	---
Tocantins	---	1
Total	645	3,895

**Source:** Elaboration of the authors based on ANEEL (2020).

With the Table 01 analysis, it is observed that most of the wind energy production in Brazil is in the territory that corresponds to the semi-arid region, which has 545 (84.49%) of the wind farms installed in the country. The installation of these parks in the region is not by chance; but because of the occurrence of winds, which are the main fuel for its production. As for solar energy, a situation contrary to that of wind energy is perceived, since the concentration of installed photovoltaic panels is in Amapá, in the northern region of the country, where 3,708 (95.19%) of these panels are located.

In the Brazilian Northeast, the geographic conditions are, in general, favorable to the generation of wind energy due to the occurrence of winds, as well as to solar energy due to the favorable climate. Consisting mostly of cities in the Northeast region (figure 01), the Brazilian semi-arid region presents a complex situation, in its various dimensions (social, economic, environmental, among others), which requires governments (national, state and local) actions aimed at reversing the situation of environmental degradation and recovery of people's quality of life, seeking, with this, the reduction of socio-environmental vulnerability and the promotion of a sustainable society. In the meantime, Anhalt (2009) points out that some measures have been adopted in order to improve the quality of life of populations in the Brazilian semi-arid region in its various aspects. Such measures include biodigesters, electric fences, solar dryers, organic agriculture irrigated with renewable energies and efficient stoves (ANHALT, 2009).

It is noticeable that the natural and built environment undergoes increasing transformations caused mainly by anthropogenic action. Deforestation, pollution of natural systems and the excessive use of fossil fuels and natural resources are some examples of

how human activities can drive this process of environmental degradation. It is in this scenario that renewable energies emerge as one of the central alternatives in controlling climate change and in the search for sustainable cities, as in addition to providing a lower environmental impact, their resources are, for the most part, inexhaustible.

Despite the growth of alternative energies in Brazil and the composition of its energy matrix, there is still no effective visualization of how much they can contribute to energy efficiency in cities (HOFSTAETTER; PESSOA, 2015a; HOFSTAETTER; PESSOA, 2015b). In these terms, it is clear that it is necessary to seek the adoption and implementation of sustainable alternatives, as is the case of renewable energy. In addition, it is necessary to integrate national climate public policies with the 2030 Agenda, a universal and historic agenda regarding the construction of a sustainable society, as discussed in the subtopic below.

### **3.4 The PNA and the 2030 Agenda: what are the alignments between them and the reverberations for cities in the Brazilian semi-arid region?**

The topic of climate change has gained space in public debate, occupying a prominent place on government agendas in several countries (GIDDENS, 2010). At the center of this discussion are the cities that, while being largely responsible for the intensification of climate change through greenhouse gas emissions (WILBANKS et al., 2007; SATTERTHWAITTE, 2008; DODMAN, 2009), exercise an important role in confronting this phenomenon from the adoption and implementation of strategies to mitigate GHG emissions and adapt to climate change (BULKELEY; BROTO, 2013; AYLETT, 2014; RYAN, 2015).

In the Brazilian context, there are many cities that suffer from the impacts of climate change. Periods of prolonged drought, especially those in the northeastern semi-arid region and which reflect on long periods of coexistence with drought, such as the one that started in 2013 and extends to the present day, are an example of these challenges resulting from climate change.

As for the perspective of climate adaptation, the country took an important step with the creation of the PNA, through Ordinance No. 2016, of May 10, 2016, which aims to carry out risk management of adverse events arising from climate change, in order to reduce national vulnerability to these changes (BRASIL, 2016). This plan is organized into 11

adaptation strategies for the sectors and topics listed as potentially vulnerable to climate change and, at the same time, a priority for the country's development (BRASIL, 2016).

Among the 11 thematic areas of the PNA, those that are intrinsically related to the SDGs are: Agriculture, Biodiversity and Ecosystems, Cities, Risk and Disaster Management, Industry and Mining, Infrastructure, Vulnerable People and Populations, Water Resources, Health, Food Security and Nutritional, and Coastal Zones (Table 02).

**Table 02 - PNA sectoral strategies aligned with the SDGs of the 2030 Agenda.**

sectoral strategy	ODS
Agriculture	SDG 2 – Zero Hunger and Sustainable Agriculture
Biodiversity and Ecosystems	SDG 15 – Life on Earth
Cities	SDG 11 – Sustainable Cities and Communities
Risk and Disaster Management	SDG 13 – Action against Global Climate Change
Industry and Mining	SDG 9 – Industry, Innovation and Infrastructure
Infrastructure	SDG 9 – Industry, Innovation and Infrastructure
Vulnerable Peoples and Populations	SDG1 – Poverty Eradication SDG 10 – Inequalities Reduction
Water resources	SDG 6 - Drinking Water and Sanitation
Health	SDG 3 – Health and Well-Being
Food and nutrition security	SDG 2 – Zero Hunger and Sustainable Agriculture
Coastal Zones	SDG 14 – Life in the Water
Water resources	SDG 6 - Drinking Water and Sanitation
Health	SDG 3 – Health and Well-Being

**Source:** Elaboration of the authors from the United Nations (UN, 2015) and PNA (BRASIL, 2016).

The strategies defined for each sector of the PNA have a strong potential for impact the realities expressed in the SDGs by understanding knowledge, practices, technologies, models, processes and services that are already available and that can be used and replicated in order to support the achievement of goals and the advancement of SDG indicators. From this perspective, one can apprehend, at least in theory, that the contribution of the PNA's sectoral strategies to achieving the goals established by the SDGs is in the sense of encouraging public administrations in the development of policies aimed at fostering the adaptive capacity of specific sectors , but which can reflect on the resilience of others.

In practice, this plan, as well as other public policies aimed at climate change, is not effective in Brazil as it establishes objectives, principles, guidelines, etc. that are not applied in realities, contributing to a lack of capacity to deal with the negative effects of climate change, confirming what Cavalcanti (2015, p. 78) signals when he states that “Brazilian cities are not prepared today for climate change , given the accumulation of socio-

environmental problems and the delay in creating adequate urban infrastructure due to exclusionary and unequal growth”.

It is evident that the consequences of climate change are even more drastic and severe for populations and territories in situations of vulnerability and socio-environmental risks (MARTINS; FERREIRA, 2011). Darela Filho et al. (2016) point out that Brazilian cities, such as those in the semi-arid region, are socially vulnerable to climate change. Faced with a scenario like this, in which it is perceived that factors such as social vulnerability and institutional limitations are strongly linked to the reality of the Brazilian semi-arid region, the response capacity of cities in this territory to the challenges posed by global and local climate change is an even greater challenge. to be faced in the coming decades.

Authors such as Teixeira and Pessoa (2020) and Teixeira, Pessoa and Di Giulio (2020) point out that one of the great challenges for the coming decades is to implement the management capacity of cities that have climate adaptation as a strategy, essential for planning urban development models from a sustainable perspective. To a certain extent, this challenge requires changes in current urban planning models, which superficially incorporate the environmental dimension in the context of urban development over the course of years.

In the case of the Brazilian semi-arid region, where social asymmetries are striking, challenges such as those mentioned require greater commitment from all segments of society, including governments at all levels of power. This is not a reality that is unique and exclusive to cities in the semi-arid region of Brazil. According to Di Giulio et al. (2019), large Brazilian cities, such as Curitiba and São Paulo, also present major challenges from the perspective of effective climate adaptive capacity due to factors such as institutional limitations and lack of political will.

Therefore, thinking about the elaboration and implementation of public policies or public urban and environmental management actions for cities in the semi-arid region or in the Brazilian territory as a whole, in order to face climate change and encourage the sustainable development of societies, is still a great and complex challenge of the national socio-environmental agenda, as presented in the following topic, with the final considerations reached with this analysis.



#### 4 FINAL CONSIDERATIONS

Globally, climate change is a major challenge to be faced, with the urbanization process making a major contribution to this phenomenon, as most of the GHG emissions caused by human activities occur in cities. Compared to developed and industrialized countries, the urbanization process in Brazil took place late, intense and disorderly.

In the context of the Brazilian Northeast, this urbanization model happened even later, more precisely, from the 1990s (VERGOLINO; DANTAS, 2005), with the occupation and use of urban land happening in an accelerated and disorderly way. As a result, problems that are already rooted in cities in the Northeast of Brazil, such as social inequalities and socio-environmental vulnerabilities, are even more intensified, especially affecting vulnerable populations and territories. This situation is reflected in the cities of the Brazilian semi-arid region, considering that they occupy almost 90% of the Brazilian Northeast.

Compared to Brazil, it is observed that the forms of occupation and use of urban territories in the Northeast and, in particular, in the semi-arid region of Brazil are even more problematic, as these territories are home to highly socially and environmentally vulnerable populations. For example, to the effects of global climate change. Examples of these effects in the context of Brazilian semi-arid cities include impacts on the region's typical biome, the Caatinga; intensification of periods of drought, with consequences for the management of water resources; and effects on food security and the economy of Brazil as a whole.

To face challenges like these, territorial planning is an extremely important instrument, as it seeks to plan cities for the occupation and use of urban land in a sustainable way, preserving resources and natural reserves, thus guaranteeing safer spaces, fair and healthy for the populations. However, in the Brazilian scenario, public policies aimed at territorial organization (Statute of the City, municipal master plans, and municipal environmental policies, among others) lack strategies aimed at building a sustainable society. Climate change, nor climate adaptation, are part of these policies.

On the national scene, climate change is not a central issue on government agendas. In the scenario of cities in the Brazilian semi-arid region, the theme follows the same direction. Specifically in relation to the perspective of climate adaptation, it is observed that this does not integrate the guidelines of urban and environmental management, even though renewable energies (such as wind and solar) are one of the main sustainable alternatives that these cities present in the perspective of facing the local climate changes.

Given the context presented, it appears that the objective proposed at the time the introductory part of this article was achieved, insofar as it was possible to reflect on the construction and implementation of adaptive capacity to climate change within cities in the Brazilian semi-arid region as a sustainability strategy. It is observed, therefore, that these cities have not walked, in general, in line with the SDGs of the 2030 Agenda, being far from achieving a sustainable future.

It is necessary to point out, in this sense, that a very worrying scenario is experienced in the national context, where there is a government system in which the urban and environmental agendas are not configured as priority strategies. From this perspective, all advances in urban and environmental management in Brazil may suffer significant setbacks that may compromise the sustainability of cities in the near future, if the 2030 Agenda is ignored at the federal, state and municipal levels. Finally, there are many challenges facing Brazilian cities from the perspective of realizing their adaptive capacities to climate change.

Within a framework of studies and research on the Society, Territory and Sustainability interface, this analysis is of paramount importance, as it contributes to the national and, above all, regional literature on cities, climate change and adaptive capacity. This article is also important for public management in cities in the Brazilian semi-arid region, as it serves as an initial diagnosis of the impacts imposed by climate change locally, enabling decision makers to design and implement public policies to combat climate change. Furthermore, this analysis is essential for populations, as they are one of the main recipients of the effects of climate change.

## REFERENCES

AMBRIZZI, T. *et al.* **Cenários regionalizados de clima no Brasil para o Século XXI: Projeções de clima usando três modelos regionais.** Relatório 3, Ministério do Meio Ambiente – MMA, Secretaria de Biodiversidade e Florestas – SBF, Diretoria de Conservação da Biodiversidade – DCBio Mudanças Climáticas Globais e Efeitos sobre a Biodiversidade – Sub projeto: Caracterização do clima atual e definição das alterações climáticas para o território brasileiro ao longo do Século XXI. Brasília: 2007. Disponível em: <[http://mudancasclimaticas.cptec.inpe.br/~rmclima/pdfs/prod\\_probio/Relatorio\\_3.pdf](http://mudancasclimaticas.cptec.inpe.br/~rmclima/pdfs/prod_probio/Relatorio_3.pdf)>. Accessed on: 07 jul. 2020.

ANEEL – Associação Nacional de Energia Elétrica. **Sistema de Informações de Geração da ANEEL (SIGA).** Brasília: ANEEL, 2020. Available on: <<https://app.powerbi.com/view?r=eyJrIjoibjI4OGYyYjQ0YWM2ZC00YjllLWJlYmEtYzdkNTQ1MTc1NmM2liwidCI6IjQwZDZmOWI4LWVjYjY0NDZmMi05MmQ0LWVhNGU5YzAxNzBIMSlmMi0jR9>>. Accessed on: 09 jul. 2020.

ANGELOTTI, F.; SÁ, I. B.; MELO, R. F de. Mudanças Climáticas e Desertificação no Semi-Árido Brasileiro. In: ANGELOTTI, F.; SÁ, I. B.; Pellegrino, G. Q. (Orgs.). **Mudanças Climáticas e Desertificação no Semi-Árido Brasileiro**. Petrolina: Embrapa Semiárido, 2009, p. 41-52.

ANGELOTTI, F.; FERNADES JR., P. I.; SA, I. B. Mudanças Climáticas no Semiárido Brasileiro: Medidas de Mitigação e Adaptação. **Revista Brasileira de Geografia Física**, v. 4, p. 1097-1111, 2011.

ANHALT, J. Tecnologias Renováveis para o Semiárido. In: OTTERLOO, Aldalice *et al.* (Orgs.). **TECNOLOGIAS SOCIAIS: caminhos para a sustentabilidade**. Brasília: s. n., 2009, p. 237-245.

ASSIS, F. R. V. *et al.* Índice de Vulnerabilidade Ambiental na Microbacia do Talhado, Santa Luzia, Paraíba. **Acta Brasiliensis**, v. 1, n. 3, p. 8-16, 2017.

AYLETT, A. **Progress and Challenges in the Urban Governance of Climate Change: Results of a Global Survey**. Cambridge, MA: MIT, 2014

BAI, X. *et al.* Six research priorities for cities and climate change. **Nature Climate Change**, 555, pp. 23-25, 2018.

BECKER, B. K. Síntese das contribuições da oficina da Política Nacional de Ordenamento Territorial. In: **Para pensar uma política nacional de ordenamento territorial**. Anais da Oficina sobre a Política Nacional de Ordenamento Territorial. Brasília, 13-14 de novembro de 2003. Ministério da Integração Nacional / Secretaria de Políticas de Desenvolvimento Regional, 2005.

BRAGA, R. Mudanças climáticas e planejamento urbano: uma análise do Estatuto da Cidade. In: **VI Encontro Nacional da Anppas**. Belém: Anais..., 2012.

BRASIL – Ministério da Integração Regional. **Para pensar uma política nacional de ordenamento territorial**: Anais da Oficina sobre a Política Nacional de Ordenamento Territorial, Brasília, 13-14 de novembro de 2003/Ministério da Integração Nacional, Secretaria de Políticas de Desenvolvimento Regional (SDR). – Brasília: MI, 2005. 78p. Disponível em:

<[https://www.mdr.gov.br/images/stories/ArquivosSNPU/Biblioteca/publicacoes/ordenamento\\_territorial.pdf](https://www.mdr.gov.br/images/stories/ArquivosSNPU/Biblioteca/publicacoes/ordenamento_territorial.pdf)>. Accessed on: 30 abr. 2020.

BRASIL – Ministério do Meio Ambiente. **Plano Nacional de Adaptação à Mudança do Clima**: Sumário Executivo. Brasília: PNA, 2016. Available on:

<[https://www.mma.gov.br/images/arquivo/80182/LIVRO\\_PNA\\_Resumo%20Executivo\\_.pdf](https://www.mma.gov.br/images/arquivo/80182/LIVRO_PNA_Resumo%20Executivo_.pdf)>. Accessed on: 30 apr. 2020.

BULKELEY, H. *et al.* Cities and climate change: the role of institutions, governance and urban planning. In: **WORLD BANK 5TH URBAN SYMPOSIUM ON CLIMATE CHANGE**. Marseille: Anais..., 2009.

BULKELEY, H.; BROTO, V. C. Government by experiment? Global cities and the governing of climate change. **Transactions of the institute of British geographers**, v. 38, n. 3, p. 361-375, 2013.

CERRI, C. C.; CERRI, C. E. P. Agricultura e aquecimento global. **Boletim Informativo da SBCS**, v.23, p. 40-44, 2007.

CASTRO, A. S.; CAVALCANTE, A. M. B. **Flores da Caatinga**. Campina Grande: Instituto Nacional do Semiárido – INSA, 2011. 116p.

CAVALCANTI, E. Vulnerabilidade, Adaptação e Capacidade Adaptativa. In: FURTADO, F.; PRIORI, L.; ALCÂNTARA, E. (Orgs.). **Mudanças Climáticas e Resiliência de Cidades**. Recife: Pickimagem, 2015, p. 75-86.

DARELA FILHO, J. P. *et al.* Socio-climatic hotspots in Brazil: how do changes driven by the new set of IPCC climatic projections affect their relevance for policy?. **Climatic Change**, v. 136, p. 413-425, 2016.

DESLAURIERS, J.; KÉRISIT, M. O delineamento de pesquisa qualitativa. In: **A pesquisa qualitativa: enfoques epistemológicos e metodológicos**, v. 2, p. 127-53, 2008.

DI GIULIO, G. M. *et al.* Bridging the gap between will and action on climate change adaptation in large cities in Brazil. **Regional Environmental Change**, v. 19, n. 8, p. 2491-2502, 2019.

DODMAN, D. Blaming cities for climate change? An analysis of urban greenhouse gas emissions inventories. **Environment and urbanization**, v. 21, n. 1, p. 185-201, 2009.

EAKIN, H., LEMOS, M. C.; NELSON, D. Differentiating capacities as a means to sustainable climate change adaptation. **Global Environmental Change**, v. 27, p. 1-8, 2014.

FREITAS, J. C. de. *et al.* Energias Renováveis, Clima e Mudanças Climáticas. **Revista Gestão & Sustentabilidade Ambiental**, v. 4, p. 317-329, 2015.

GIDDENS, A. **A política da mudança climática**. Trad. Vera Ribeiro. Rio de Janeiro: Zahar. 2010. 314 p. Tradução de: The politics of climate change.

GONDIM, J. *et al.* A seca atual no Semiárido nordestino—Impactos sobre os recursos hídricos. **Parcerias Estratégicas**, v. 22, n. 44, p. 277-300, 2017.

GRAY, C.; MUELLER, V. Drought and population mobility in rural Ethiopia. **World development**, v. 40, n. 1, p. 134-145, 2012.

HARVEY, D. **A produção capitalista do espaço**. São Paulo: Annablume, 2005.

HOFSTAETTER, M.; PESSOA, Z. S. Impactos Socioambientais e Regionais da Energia Eólica no Rio Grande do Norte. In: **7º Encontro Nacional da Anppas**. Anais..., 2015a.

HOFSTAETTER, M.; PESSOA, Z. S. ENERGIA EÓLICA: um novo debate, entre defesas

e contradições. In: **VII Jornada Internacional de Políticas Públicas**. Anais..., 2015b.

HOGAN, D. J. População e mudanças ambientais globais. In: HOGAN, D. J. MARANDOLA JR., E. (Org.). **População e mudança climática: dimensões humanas das mudanças ambientais globais**. Campinas: Ed. Unicamp, 2009, p. 11-24.

IBGE – Instituto Brasileiro de Geografia e Estatística. **Censo 2010**. Brasília: IBGE, 2010. Disponível em: <<https://censo2010.ibge.gov.br/>>. Acesso em: 05 jul. 2020.

IPCC – Painel Intergovernamental sobre Mudanças Climáticas. **Climate Change 2007: Impacts, Adaptation and Vulnerability**. United Kingdom: Crown. 2007 – Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. 2007. Available in: <[https://www.ipcc.ch/site/assets/uploads/2018/03/ar4\\_wg2\\_full\\_report.pdf](https://www.ipcc.ch/site/assets/uploads/2018/03/ar4_wg2_full_report.pdf)>. Accessed on: 28 apr. 2020.

LECK, H.; ROBERTS, D. What lies beneath: understanding the invisible aspects of municipal climate change governance. **Current Opinion in Environmental Sustainability**, v. 13, p. 61-67, 2015.

MADEIROS, H.; GRIGIO, A.; PESSOA, Z. Desigualdades e justiça ambiental: um desafio na construção de uma cidade resiliente. **GOT, Revista de Geografia e Ordenamento do Território**, n. 13, p. 247-265, 2018.

MARENGO, J. A. Vulnerabilidade, impactos e adaptação à mudança do clima no semiárido do Brasil. **Parcerias Estratégicas**, vol. 13, n. 27, p. 149-176, 2008.

MARENGO, J. A. *et al.* Future change of temperature and precipitation extremes in South America as derived from the PRECIS regional climate modeling system. **International Journal of Climatology: A Journal of the Royal Meteorological Society**, v. 29, n. 15, p. 2241-2255, 2009.

MARENGO, J. A. *et al.* Variabilidade e mudanças climáticas no semiárido brasileiro. **Instituto Nacional do Semiárido**, Campina Grande – PB, v. 1, p. 383-422, 2011.

MARICATO, E. **Meio Ambiente e Reforma Urbana**. Meio Ambiente e Reforma Urbana. Setembro, 1994.

MARICATO, E. MetrÓpole, legislação e desigualdade. **Estudos avançados**, v. 17, n. 48, p. 151-166, 2003.

MARICATO, E. The future of global peripheral cities. **Latin American Perspectives**, v. 44, n. 2, p. 18-37, 2017.

MARTINS, R. D. A.; FERREIRA, L. da C. Uma revisão crítica sobre cidades e mudança climática: vinho velho em garrafa nova ou um novo paradigma de ação para a governança local?. **Revista de Administração Pública**, v. 45, n. 3, p. 611-641, 2011.

MORAES, A. C. R. Ordenamento territorial: uma conceituação para o planejamento

estratégico. In: MORAES, A. C. R. (Org.). **Meio ambiente e ciências humanas**. 4ª. ed. São Paulo: Annablume, p. 139-149, 2005.

OJIMA, R. Urbanização, dinâmica migratória e sustentabilidade no semiárido nordestino: o papel das cidades no processo de adaptação ambiental. **Cadernos Metrópole**, v. 15, n. 29, p. 35-54, 2013.

ONU – Organização das Nações Unidas. **17 objetivos para transformar o nosso mundo**. Nova Iorque: ONU, 2015. Available on: <<https://nacoesunidas.org/pos2015/>>. Accessed on: 23 out. 2017.

PBMC – Painel Brasileiro de Mudanças Climáticas. **SUMÁRIO EXECUTIVO – IMPACTOS, VULNERABILIDADES E ADAPTAÇÃO**. Contribuição do Grupo de Trabalho 2 ao Primeiro Relatório de Avaliação Nacional do Painel Brasileiro de Mudanças Climáticas. Rio de Janeiro: PBMC, 2013. 28 p. Available on: <[http://www.pbmc.coppe.ufrj.br/documentos/GT2\\_sumario\\_portugues\\_v2.pdf](http://www.pbmc.coppe.ufrj.br/documentos/GT2_sumario_portugues_v2.pdf)>. Accessed on: 25 jun. 2020.

RÜCKERT, A. A. Reforma do Estado, reestruturações territoriais, desenvolvimento e novas territorialidades. **GEOUSP - Espaço e Tempo**, São Paulo, n. 17, p. 79-94, 2005.

RÜCKERT, A. A. A Política Nacional de Ordenamento Territorial, Brasil. Uma política territorial contemporânea em construção. **Scripta Nova: revista electrónica de geografía y ciencias sociales**, v. 11, 2007.

RYAN, D. From commitment to action: a literature review on climate policy implementation at city level. **Climatic Change**, v. 131, n. 4, p. 519-529, 2015.

SALAZAR, L. F.; NOBRE, C. A.; OYAMA, M. D. Climate change consequences on the biome distribution in tropical South America. **Geophysical Research Letters**, v. 34, n. 9, 2007.

SANTOS, M. **A urbanização brasileira**. 5. ed. São Paulo: Editora da Universidade de São Paulo, 2005.

SATTERTHWAITE, D. Climate change and urbanization: Effects and implications for urban governance. In: **United Nations Expert Group meeting on population distribution, urbanization, internal migration and development**. DESA New York, 2008. p. 21-23.

SILVA, A. L. de S.; SILVA, L. C. S.; PESSOA, Z. S. Energia Eólica e Solar: Produção no Brasil e o impacto socioambiental nos municípios do Rio Grande do Norte (RN). In: Encontro Nacional de Ensino e Pesquisa do Campo de Públicas (ENEPCP), 3. **Anais...**, 2019.

SILVA, P. C. G. da. *et al.* Caracterização do Semiárido brasileiro: fatores naturais e humanos. In: SÁ, I.B.; SILVA, P.C.G. da. (Orgs.). **Semiárido Brasileiro: Pesquisa, Desenvolvimento e Inovação**. 1. ed. Brasília: Embrapa Informação Tecnológica, 2010, v. 1, p. 17-48.

SUDENE – SUPERINTENDÊNCIA DO DESENVOLVIMENTO DO NORDESTE. **NOTA TÉCNICA Nº 05/2017/CGDS/DPLAN/SUDENE**. Recife: SUDENE, 2017, 5p. Available on: <[http://sudene.gov.br/images/2017/arquivos/NOTA T%C3%89CNICA n%C2%BA\\_05 - 2017.pdf](http://sudene.gov.br/images/2017/arquivos/NOTA_T%C3%89CNICA_n%C2%BA_05_-_2017.pdf)>. Accessed on: 09 jul. 2020.

TEIXEIRA, R. L. P.; PESSOA, Z. S. MUDANÇAS CLIMÁTICAS, EXPERIMENTAÇÃO DE POLÍTICAS PÚBLICAS E CAPACIDADE ADAPTATIVA NA CIDADE DE CURITIBA/PR-BRASIL. **Revista Inter-Legere**, v. 3, n. 27, p. 1-28, 2020.

TEIXEIRA, R. L. P.; PESSOA, Z. S.; DI GIULIO, G. M. Mudanças Climáticas E Capacidade Adaptativa no Contexto da Cidade Do Natal/RN, BRASIL. **Revista Geotemas**, v. 10, n. 1, p. 95-115, 2020.

TORRES, R. R. *et al.* Socio-climatic hotspots in Brazil. **Climatic change**, v. 115, n. 3-4, p. 597-609, 2012.

VERGOLINO, J. R.; DANTAS, M. Os determinantes do processo de urbanização da região nordeste do Brasil: 1970-1996. **Revista de Economia**, v. 31, n. 2, 2005.

WILBANKS, T. J. *et al.* Industry, settlement and society. In: **Climate Change 2007: Impacts, Adaptation and Vulnerability**, Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, 2007. p. 357-390. Disponível em: <<https://www.ipcc.ch/site/assets/uploads/2018/02/ar4-wg2-chapter7-1.pdf>>. Accessed on: 30 apr. 2020.

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