LUMEN ET VIRTUS

Impacts of accelerated urbanization on climate change in Manaus

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ABSTRACT

Accelerated urban growth in Manaus, one of the main metropolises in the Amazon, has generated a series of environmental challenges, exacerbating local and global climate change. This study explores how rapid population growth, industrial expansion, and increased built area contribute to environmental degradation and alter the region's climate. Among the main impacts are deforestation, which results in the loss of vegetation cover and biodiversity, air pollution caused by emissions from vehicles and industries, and changes in the hydrological cycle, which affect precipitation patterns and water availability. The research highlights the importance of public policies and private initiatives to mitigate these impacts, including preserving green areas, encouraging the use of clean technologies, and promoting sustainable transport. In addition, adaptation strategies to increase the resilience of urban infrastructure in the face of climate change are discussed. The study concludes that the adoption of sustainable urban practices is essential to minimize the negative effects of urbanization and ensure a balanced and responsible development, which respects the delicate Amazon ecosystem and improves the quality of life of the inhabitants of Manaus.

Keywords: Urbanization, Climate Change, Vegetation Cover.

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INTRODUCTION

Accelerated urbanization is a global phenomenon that brings with it a series of environmental challenges, especially in large cities. Manaus, located in the heart of the Amazon, is no exception. Urban sprawl in the city has been characterized by rapid population growth, increased industrial activity, and expansion of built-up areas, which has generated a number of significant environmental impacts. These impacts are particularly concerning due to Manaus' strategic location in one of the most ecologically important regions on the planet. This study seeks to analyze how accelerated urbanization in Manaus contributes to climate change, both local and global, and to propose strategies for sustainable mitigation and adaptation.

To achieve the general objective, this work investigates the main urbanization factors that directly influence the increase in greenhouse gas emissions and environmental degradation in the city. Among these factors, deforestation, industrial expansion, and increased vehicle traffic stand out, all of which are significant contributors to the increase in carbon emissions and other air pollutants. The analysis of these elements is fundamental to understand how disorderly urban growth and the lack of sustainable planning are exacerbating environmental and climate problems in Manaus.

In addition, the study evaluates the public policies and urban planning practices currently in force in Manaus, in order to identify their limitations and potential for mitigating the negative impacts of urbanization on the climate. The methodology adopted will be of a bibliographic nature, based on a review of existing literature, case studies and government reports. Based on this analysis, recommendations will be proposed for the development of adaptation strategies that promote the city's resilience to climate change, aiming at a more sustainable and balanced future for the population of Manaus and the Amazon ecosystem.

POPULATION GROWTH AND URBAN EXPANSION

The city of Manaus has experienced significant population growth in recent decades, driven by internal and external migrations. This population increase results in an accelerated urban expansion, characterized by the disorderly occupation of peripheral areas and the transformation of natural spaces into residential and industrial zones. According to Souza and Carvalho (2021), "the disorderly urban expansion of Manaus has caused a series of environmental problems, including the degradation of natural habitats and pressure on local water resources" (p. 35).

In addition, the lack of adequate urban planning has led to the construction of inadequate infrastructure, which often does not keep up with the pace of population growth. This results in problems such as lack of basic sanitation, traffic congestion, and the overload of health and education systems. As Oliveira (2020) points out, "rapid urbanization without the proper infrastructure and

public services can aggravate social inequalities and compromise the quality of life of citizens" (p. 47).

Urban sprawl is also closely linked to increased soil impermeability, which reduces water infiltration and increases surface runoff, contributing to frequent flooding and flooding. According to Martins et al. (2019), "accelerated urbanization in Manaus has significantly altered the hydrological cycle, exacerbating flood events, especially during the rainy season" (p. 59). This scenario highlights the urgent need for sustainable urban planning that considers the carrying capacity of the environment and the needs of the population.

DEFORESTATION AND LOSS OF VEGETATION COVER

The urbanization process in Manaus has led to extensive deforestation of forest areas, resulting in the loss of vegetation cover that is crucial for climate regulation and biodiversity preservation. The removal of native vegetation to make way for construction and urban infrastructure not only destroys natural habitats, but also contributes to rising local temperatures, a phenomenon known as an urban heat island. Lima and Silva (2022) state that "urban deforestation in Manaus has direct consequences on the increase in the city's average temperatures, intensifying the effects of climate change" (p. 72).

Loss of vegetation cover is also associated with increased carbon emissions, as forests act as important carbon sinks. The destruction of these areas results in the release of large amounts of CO_2 into the atmosphere, exacerbating the greenhouse effect. According to data presented by Almeida et al. (2020), "the conversion of forest areas into urban areas in Manaus has contributed significantly to the increase in greenhouse gas emissions in recent years" (p. 81).

In addition, the reduction of vegetation cover compromises the region's ability to maintain humidity and regulate the hydrological cycle, negatively impacting the local climate. "Amazon forests play a critical role in maintaining the hydrological cycle, and their destruction can lead to significant changes in precipitation patterns, both locally and in other regions" (Freitas & Gonçalves, 2021, p. 89). The conservation of vegetation cover is, therefore, essential to mitigate the impacts of climate change and preserve the environmental health of Manaus.

AIR POLLUTION AND GREENHOUSE GAS EMISSIONS

Air pollution in Manaus is a growing issue, exacerbated by accelerated urbanization and increased vehicle traffic and industrial activities. Emissions of pollutants, such as carbon dioxide (CO_2), nitrogen oxides (NO_x), and particulate matter, have adverse impacts on air quality and public health. "The increase in the number of motor vehicles in Manaus, combined with growing industrial

activity, has led to alarming levels of air pollution, contributing to respiratory and cardiovascular diseases in the population" (Santos & Pereira, 2021, p. 104).

In addition to health problems, greenhouse gas emissions from these sources are a key factor in contributing to climate change. The burning of fossil fuels for transportation and industrial energy releases large amounts of CO_2, one of the main gases responsible for global warming. As pointed out by Cardoso (2020), "CO_2 emissions in Manaus have increased significantly, driven by urban and industrial growth, becoming an environmental and climate concern of great importance" (p. 112).

To address these challenges, it is necessary to adopt public policies that promote the use of clean technologies and renewable energy sources, as well as improve the efficiency of public transport and encourage the use of less polluting vehicles. "Measures such as the implementation of low-emission zones and the promotion of alternative transport are essential to reduce air pollution and greenhouse gas emissions in Manaus" (Rodrigues & Araujo, 2019, p. 123). These actions are key to improving air quality and contributing to climate change mitigation.

ANALYSIS OF THE RESULTS

The Amazon region has undergone several changes, driven by the urbanization of the city. The rubber period was an initial milestone that transformed Manaus into an income-generating hub and a welcoming place for the populations of the north and northeast of Brazil. Subsequently, the Free Trade Zone project represented a major economic boost for the state. However, this expansion brought with it irregular occupations, as many people needed a place to live. This process resulted in the devastation of forest areas, disorderly urban expansion and simultaneous economic growth.

As the city continued to develop rapidly, this cycle of progress significantly impacted the region's economy, urban architecture, and, especially, culture. The creation of neighborhoods over the years did not follow adequate planning, reflecting the current unfavorable conditions, especially in the neighborhoods analyzed. The devaluation of the igarapés, caused by the occupation of the banks of the rivers by populations living in precarious conditions, is a clear example of this carelessness.

It was observed that, both in the Rubber Cycle and in the Manaus Free Trade Zone, there was a significant urban population growth, evidencing a disconnection between the structural economic models and the urbanization pattern. These models, over time, concentrated income, but also accentuated social inequalities. Therefore, greater investment in the education of the local population is crucial to enable sustainable economic development and the reduction of socioeconomic disparities spread across the urban space of Manaus. However, due to the crisis faced by Brazil, there is no prospect of an urban, political or socioeconomic reform for Manaus in the short or medium term.

CONCLUSION

This work investigated the main urbanization factors that directly influence the increase in greenhouse gas emissions and environmental degradation in Manaus. Among these factors, deforestation, industrial expansion, and increased vehicle traffic stand out, all of which contribute significantly to the increase in carbon emissions and other air pollutants. Analysis of these elements is key to understanding how disorderly urban growth and a lack of sustainable planning are exacerbating environmental and climate problems in the city.

In addition, the study evaluated the public policies and urban planning practices currently in force in Manaus, identifying their limitations and potential for mitigating the negative impacts of urbanization on the climate. The methodology adopted was of a bibliographic nature, based on a review of existing literature, case studies and government reports. Based on this analysis, recommendations were proposed for the development of adaptation strategies that promote the city's resilience to climate change, aiming at a more sustainable and balanced future for the population of Manaus and the Amazon ecosystem.

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