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Micromobility in Urban Centers: An Approach for Smart and Sustainable Cities

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ABSTRACT
The concept of smart cities has become increasingly relevant in the contemporary contexto. Smart Cities improve the quality of life for urban residents through the integration of technology, innovation, and sustainability in various aspects of urban life. In this regard, micromobility, with the adoption of small electric vehicles, emerges as a promising solution to address transportation challenges in densely populated urban areas. This paper will explore the role of micromobility in urban centers, particularly in the city of São Paulo, Brazil, discussing its potential contributions to the development of smart and sustainable cities.

KEYWORDS: Smart Cities, Urban Micromobility, Urban Core, Small Electric Vehicles.

1 INTRODUTION

Urban mobility is one of the main challenges of contemporary cities, especially in developing countries like Brazil. The increase in population, with the consequent raise in transportation demand and environmental pollution requires innovative and sustainable solutions to improve the quality of life for citizens.

Urban centers represent the epicenter of modern human life, where a myriad of social, economic, and cultural activities converge to create the vibrant essence of cities. Throughout history, urban centers have been the primary catalysts of human development, driving innovation, diversity, and progress. In these population clusters, we find a complex interaction between physical, social, and technological infrastructure that shapes how we live, work, and relate to one another. Within this context, the concept of urban micromobility emerges leading to the use of lightweight, electric, and shared vehicles, such as bicycles, scooters, unicycles, tricycles, and small vehicles to, make short and medium-distance trips in urban areas.

In this way, urban micromobility is drawn into the concept of smart cities, which seeks to integrate technology, urban planning, and management to promote the economic, social, and environmental development of cities. Considering the low impact of micro-vehicle mobility (micromobility) on the demand for urban space and environmental resources, contributing to overall urban sustainability, micromobility plays a fundamental role in ensuring environmental preservation with lower greenhouse gas (GHG) emissions and improving the well-being of people living in the city. In this article, we will analyze the advantages, challenges, and prospects of intelligent and sustainable urban micromobility using small electric vehicles.

2 OBJECTIVE

In this article one discusses urban mobility in cities, analyzing the advantages, challenges, and prospects of urban micromobility, with a focus on the use of small electric vehicles for short and medium-distance trips within the broader context of smart and sustainable cities.

3 RESEARCH METHODOLOGY

The research methodology used in this article involves a systematic literature review, with the identification, selection, and analysis of relevant studies on the topic.

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The research is grounded in micromobility in urban centers within the context of smart cities, focusing on the use of small electric vehicles to improve people's mobility over short and medium distances, and providing a better quality of life in a more humane, sustainable way with lower greenhouse gas emissions. The multidisciplinary approach allows for a comprehensive understanding of the challenges and opportunities associated with urban mobility, as well as best practices for promoting smart and sustainable cities.

The literature review was conducted through searches in academic databases such as ResearchGate, Google Scholar, MDPI, and Web of Science, using relevant search terms such as "smart cities," "small electric vehicles," "urban micromobility," "sustainable development," and "sustainable cities." Studies that addressed the intersection of these themes, providing opportunities and challenges in the adoption of small electric vehicles in an urban context, were selected.

4 LITERATURE REVIEW

Cities emerge as major centers of innovation, opportunity, and challenges. Growing urbanization is redefining the way we live, work, and interact with the environment around us. Thus, the concept of smart cities arises as an innovative and efficient response to the complex urban problems faced by communities around the world. In this context, we will provide a brief review of some important concepts found in the literature.

4.1 Smart Cities

Smart cities are those cities that use technology and data, meaning city information, to improve the quality of life for their inhabitants, increase the efficiency of public services, and promote sustainable development. These cities integrate various areas, such as transportation, energy, communication, health, and safety, through the umbrela of innovative technological solutions.

It is worth highlighting that the efficient management of resources is fundamental to the sustainability of smart cities. This includes the management of renewable energy systems, efficient waste management, water conservation, well-planned green spaces, and smart mobility (including innovative transportation solutions such as electric vehicles, bike-sharing, and efficient public transportation) through smart systems and applications that help reduce congestion and improve accessibility within the city. Within this context, urban micromobility also emerges as an important strategy to achieve this goal (PORTO et al., 2020).

4.2 Sustainable Cities

Sustainable cities are those that adopt smart practices and efficient public policies to improve people's quality of life, focusing on environmental preservation. In sustainable cities, urban centers are organized to avoid the depletion of natural resources and environmental degradation, ensuring a healthier life and environmental preservation. Public policies cover education, work, health, leisure, social assistance, environment, culture, housing, and

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transportation (CIÊNCIA&CULTURA, 2023). Moreover, these cities should promote public spaces that encourage health, well-being, productivity, access to basic resources, and sustainable economic development.

Urban mobility is a major concern in sustainable cities because fossil fuel vehicles, are harmful to environmental sustainability due to CO_2 emissions, which contribute to global warming. Sustainable cities invest in public transportation infrastructure, such as electric mobility, and promote alternatives like cycling and walking to encourage the reduction of polluting vehicle use (HABITABILITY, 2022).

4.3 Micromobility in Urban Centers

Micromobility refers to the use of lightweight, low-speed personal transportation modes for short-distance travel within urban areas. These vehicles offer an alternative to traditional modes of transportation, such as private cars and public transportation, especially for "last-mile" trips, i.e., between public transit stations and final destinations (PRICE, et al., 2021).

The concept of an urban centers refers to the central area of a city or municipality where commercial, administrative, cultural, and residential activities are concentrated. It is the city's beating heart, where intense interaction between people and institutions occurs. The urban center is usually characterized by higher population density, developed infrastructure, concentration of commercial buildings, large department stores, and a mix of land uses such as commerce, services, and housing.

In the work "The Right to the City" (LEFEBVRE, 1968), the French sociologist and urban planner Henri Lefebvre deeply discusses the importance of the urban center and urban life, addressing issues related to the access and use of urban space, the role of politics in shaping cities, and the need for a more democratic and participatory approach to city management. His ideas have significantly influenced urban planning thought and continue to be debated and studied to this day.

4.4 Vehicles for Micromobility

Vehicles designed for micromobility are generally characterized by being lightweight, agile, and suitable for short trips within urban areas. These vehicles can include traditional bicycles (conventional and electric, with pedal assist or self-propelled), electric scobinets, electric scooters, electric tricycles, and micro electric vans (commonly known as "tuk tuks"). These vehicles can be used as an alternative to cars and utility vehicles for activities that require short to medium-distance travel (up to 40 km) within cities and can also be shared through app-based rental services. These vehicles offer a convenient and often sustainable alternative to traditional modes of transportation, especially for short-distance travel in congested urban environments (PRICE, et al., 2021).

5 THE CASE FOR MICROMOBILITY FOR BRAZILIAN LARGE CITIES

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When considering micromobility and its synergy with the concepts of smart cities, we can identify several scenarios that meet the needs of urban centers. By considering the situation in Brazil, even without an adequate policy for urban mobility, we can observe an increase in the utilization of micromobility in recent years with the use of shared bicycles and scooters. These results are being achieved in spite of the still limited developer of effective policies aimed at making this new mode of transportation viable compared to traditional means.

It is important to highlight that the attempt to introduce shared electric scooters yielded interesting results, but due to factors such as legislation, city infrastructure, vandalism, theft, and misuse it did not achieve the expected goals of micromobility and sustainability. This experience was also fairly limited, with its use reaching only major urban centers such as São Paulo, Rio de Janeiro, Brasília, Belo Horizonte, Curitiba, and Porto Alegre, among others.

In our discussion, we must reflect on how Brazilians live in large cities and what is most important to them, remembering that talking about smart cities ultimately means working to improve social well-being. Due to cultural reasons, it is widely recognized that Brazilian society, in general, has a strong preference for mobility through the use of individual vehicles in their daily activities, such as work, school, and leisure. Motives like, convenience, freedom, status, deficiencies in public transportation, among others, may be pointed out as the main reasons behind this behavior.

These findings are confirmed in the study by the EY Agency - Building a better working world, where Brazilian drivers rank among those with the highest average car use for work or study. In the survey conducted in 20 countries, out of a total of 15,000 respondents, 1,001 were from Brazil, and 88% responded that they prefer to use their personal vehicle daily, compared to a global average of 80%.

On the other hand, regarding the use of public transportation for the same purpose, only 56% of Brazilians stated that they rely on it, compared to 62% of the global average. This percentage is lower than that found in other developing countries such as India, with 85%, and Mexico, with 66% (AGÊNCIA EY, 2023).

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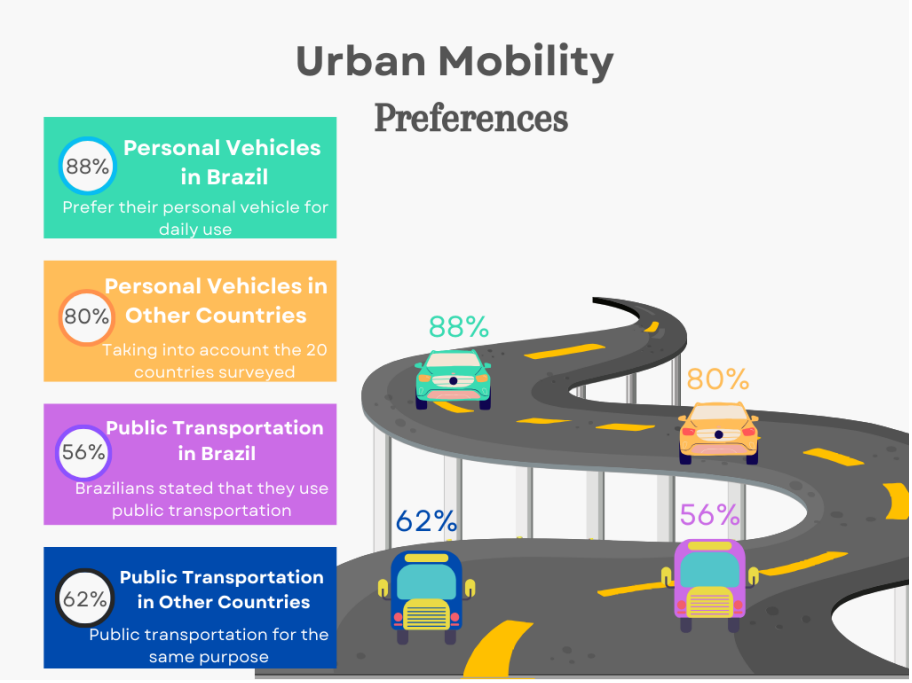
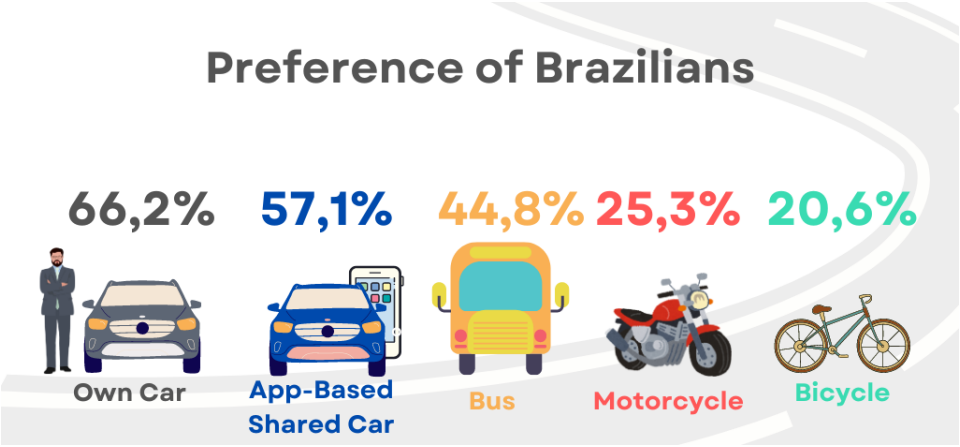
Figure 1 – Dataflow *EY Agency Study*



Source 1: *AGÊNCIA EY, 2023;* Drawing by the author, 2024

The research commissioned by Localiza, a car rental company, in the report "Trends in Mobility and Travel in Brazil," states that 66% of Brazilians still prefer their own car for daily use. The results show that the automobile is the most used mode of transportation for more than half of the respondents (66.2%), with personal cars continuing to be the main mode of transport, followed by app-based shared cars (57.1%), buses (44.8%), motorcycles (25.3%), and bicycles (20.6%). Rental cars rank eighth, with 16.9% of participants, as shown in Figure 2 (BIANCHIN, 2021).

Figure 2 – *Preference of Transportation in Brazil*



Source 2: *BIANCHIN, 2021;* Drawing by the author, 2024

A The analysis of this data leads to the need to seek transportation alternatives that meet sustainability requirements with environmental preservation, be attractive to Brazilian

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preferences, and improve vehicle traffic while fulfilling the criteria for a smart and sustainable city.

But what would these alternatives be? Certainly, an important result that allows us to answer this question for the city of São Paulo would be to determine the distance traveled by Paulistanos in their daily commuting within the urban center. This information can be obtained from the National Urban Mobility Survey – Pemobe, which, in its field "Considering all modes of transportation and origin-destination (O/D) surveys conducted, what is the average distance of trips? (In km)," shows that, for the São Paulo Metropolitan Region, trips are, on average, 5.3 km in radius, meaning short trips that justify a vehicle designed for urban transit and to take Brazilians to work, school, or leisure, thus meeting their main mobility needs (BRASIL, 2023).

According to Portal Mobilize Brasil, two-thirds of the trips made by Paulistanos stay within a 5 km radius of their starting point, demonstrating that for most of these trips na economical, sustainable, and non-polluting vehicle, such as small electric vehicles, could be used (MOBILIZE BRASIL, 2018).

With all this information, it is clear that to meet the requirements of economy and sustainability, preserving the environment and reducing city congestion, the use of electric micromobility can be a suitable urban mobility policy.

Figure 2 - Small Electric Vehicle

Source: Author's Collection, 2023

This is justified because small electric vehicles, which can carry between one and two persons, are ideal for navigating narrow and congested streets, providing greater agility in urban traffic. Their maneuverability facilitates movement in tight spaces, contributing to more efficient mobility.

Let us now analyze the advantages and disadvantages of this policy.

5.1. Advantages of Small Electric Vehicles

5.1.1 Sustainable Mobility: Small electric vehicles offer a sustainable alternative to fossil fuel-powered vehicles, helping to reduce greenhouse gas (GHG) emissions and air pollution in urban centers (HOSSAIN et al., 2022);

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5.1.2 Reduction of Traffic and Congestion: Due to their compact size, these vehicles are more agile and occupy less road space, which can contribute to reducing congestion and improving traffic flow in congested urban areas;
5.1.3 Ease of Parking: Small electric vehicles are easier to park in limited spaces, helping to alleviate parking problems in crowded urban centers;
5.1.4 Lower Operating Costs: Compared to fossil fuel-powered vehicles, small electric vehicles generally have lower operating costs, primarily due to electricity being cheaper per kilometer than gasoline or diesel;
5.1.5 Meeting Daily Urban Mobility Demand: Most small electric vehicles have a range of 20 km to 40 km on a full charge, which perfectly meets the average daily urban commute needs of people (ALANAZI, 2023).

5.2 Disadvantages of Small Electric Vehicles

5.2.1 Range Limitations: Many small electric vehicles have a limited range compared to fossil fuel-powered vehicles, which can limit their utility for longer trips or routes without adequate charging infrastructure;
5.2.2 Charging Time: The time required to recharge electric vehicle batteries can be significant, especially compared to the time needed to refuel a traditional vehicle;
5.2.3 Higher Initial Cost: Electric vehicles tend to have a higher initial cost than fossil fuel-powered vehicles, which can hinder widespread adoption, especially in developing countries;
5.2.4 Limited Charging Infrastructure Availability: In many urban areas, charging infrastructure for electric vehicles is still limited, which can hinder consumer adoption (ALANAZI, 2023).

6 CONCLUSION

The adoption of micromobility with small electric vehicles represents a significant step towards building smarter and more sustainable cities. This paper explored the transformative potential of these innovative solutions, highlighting their ability to mitigate the urban mobility challenges faced by many Brazilian large cities, such as São Paulo. By facilitating efficient and accessible transportation, these vehicles not only reduce street congestion but also contribute to lowering greenhouse gas emissions.

Small electric vehicles have the potential to transform our cities, making them cleaner, more efficient, and sustainable. With proper planning and implementation of appropriate policies, these vehicles can play a crucial role in creating smart and sustainable cities.

Despite the current trend towards greater social awareness of sustainable transportation, and the increased use of bicycles and electric scooters, there remains a significant percentage of people who do not give up their cars as their primary mode of transportation. To cater to this audience, car manufacturers have been developing electric and/or hybrid vehicles as an alternative to combustion engines. Positive results have emerged with the adoption of electric models, which have evolved rapidly in recent years. With modern designs, increased efficiency, and greater autonomy, electric models are winning over new drivers worldwide each year (RENAULT, 2021).

However, significant challenges remain for the adoption of small electric vehicles.

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These include limited charging infrastructure, longer charging times, higher initial costs, and limited range. Therefore, it is crucial to develop public policies, supported by planning and appropriate legislation, to address these challenges and facilitate the transition to electric mobility.

In conclusion, small electric vehicles can represent a promising approach to creating smart and sustainable cities. They offer a range of benefits, including energy efficiency, reduced air pollution, and lower operational costs.

Thus, this approach is fully aligned with global sustainability trends, meeting the goals for developing smart, humane, and sustainable cities.

7 FUTURE WORK

Despite their advantages, the successful integration of micromobility into urban centers faces some challenges, including safety issues, regulation, infrastructure, and public acceptance. To maximize the benefits of micromobility, careful urban planning, investment in infrastructure for new vehicles, and progressive transportation, policies that encourage the use of sustainable transportation modes are necessary.

Despite the challenges, the future of micromobility looks promising. With the support of appropriate public policies and investments in infrastructure, micromobility vehicles have the potential to play a key role in urban mobility for smart cities. Additionally, integration with public transportation systems could offer users more flexible and efficient travel options.

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