REDESIGNING URBAN MORPHOLOGY WITH RESPECT TO SUSTAINABLE DECISIONS

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Abstract
Redesigning urban morphology with sustainability in mind is crucial given rapid global urbanization and climate challenges of climate change, resource depletion, and socioeconomic disparities. This research explores reshaping the fundamental concept of urban spaces to prioritize sustainability, stressing the importance of environmentally and socially responsible city planning. Considerations include the environmental impact of buildings, transportation, and land use. Furthermore, it underscores the importance of community engagement and collaboration among stakeholders to ensure that the built environment is efficient and responsive to the needs and aspirations of the urban population. Case studies like Curitiba in Brazil demonstrate the feasibility and benefits of sustainable urban development, adapting to local conditions and culture while mitigating environmental impacts. Analytical research seeks to identify factors influencing urban morphology and develop suitable strategies for future sustainable urban development. Prioritizing sustainability promises to create liveable, environmentally friendly cities.

1. Introduction

Urban morphology, the study of the physical structure and form of cities, plays a pivotal role in shaping the sustainability and liveability of urban environments [1]. As urbanization accelerates globally, coupled with the pressing challenges of climate change, resource depletion, and socioeconomic disparities, the need to redesign urban spaces with sustainability as a priority becomes increasingly urgent. In recent years, cities around the world have been facing some tough challenges. With more and more people moving into urban areas, cities are struggling to keep up with the demand for things like housing and transportation. This rapid growth is putting a strain on natural resources and making pollution worse, which is bad news for both people's health and the environment [2]. Additionally, we're seeing more and more extreme weather events like hurricanes, floods, and wildfires, all linked to climate change. These disasters are hitting cities hard and showing us just how vulnerable they can be. That's why there's a growing sense that we need to come up with new and innovative ways to plan and design cities. We need to make sure that our cities are not only sustainable but also able to recover from challenges and include everyone in the process [3]. This research explores the intricate relationship between urban morphology and sustainability, emphasizing the importance of environmentally and socially responsible city planning [4]. The primary aim of this

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research is to investigate the process of reshaping urban morphology to prioritize sustainability. By analysing case studies and conducting an analytical study, this research seeks to identify critical factors influencing urban morphology and develop strategies for future sustainable urban development. The research addresses this problem by studying how rapid urbanization and the mounting challenges of climate change pose significant threats to the well-being of urban residents and the ecological integrity of urban areas. Addressing these challenges requires a comprehensive understanding of urban morphology and a concerted effort to integrate sustainability principles into urban planning and design. This research employs a multi-faceted approach, incorporating qualitative analysis of case studies, such as the exemplar of Curitiba, Brazil, to elucidate the feasibility and benefits of sustainable urban development. The research is structured into sections, including an introduction, literature review, methodology, discussion, and conclusion. The literature review explores surveys of existing literature on urban morphology, sustainability, and urban planning, establishing the theoretical framework for the study. The Conclusion Summarizes key findings and implications, highlighting the importance of prioritizing sustainability in urban morphology.

2. Methods and tools

In analysing the methodology, a structured approach is employed to meticulously examine the intricate relationship between urban morphology and sustainable urban planning. The methodology hinges on a comprehensive literature review to establish a robust theoretical foundation, elucidating key concepts and methods relevant to the study. Subsequently, the research will analyze the case study of Curitiba in Brazil, where sustainable thinking affected urban morphology. Moreover, it will analyze the urban planning process of Curitiba (Effective public bus system of Curitiba & Evolution of the integrated Transit network, Local environmental awareness and citizens' participation, Local waste management system, Natural disaster management, and Pedestrian priority and heritage rehabilitation) and how it affects the urban morphology by time. The analysis incorporates diverse data collection methods, such as literature review, archival research, and case study, ensuring a holistic understanding of the subject matter. By integrating findings from the literature review and case study analysis, this methodology provides valuable insights into the dynamic interplay between sustainable urban development and urban form.

3. Literature review

Urban morphology indeed serves as a bridge between various disciplines within the fields of urban design and planning. The intersection between geography and architecture is particularly evident in studying urban form and structure [5]. The empowerment of decision-making in urban planning, the thoughtful design of transportation networks and urban block patterns, and the prioritization of sustainability in upgrading are all pivotal in shaping urban morphology [6]. These factors collectively influence how cities evolve, impacting their functionality, sustainability, and quality of life for residents [7]. Effective urban planning and design consider these elements comprehensively, aiming to create well-structured cities that are responsive to their inhabitants' needs. As urban areas evolve, urban morphologists need to consider these dynamics and actively work towards creating urban spaces responsive to changing lifestyles and supportive of sustainability objectives. By reflecting on and pursuing their role in the search for sustainability in urban morphology, they can contribute to creating more environmentally responsible and socially inclusive cities [8]. The arrangement and organization of urban elements (such as buildings, streets, and public spaces) influence the characteristics and behavior of the city. Understanding this "inner structure" is essential for urban planners and designers to make informed decisions about urban development and design [9]. The cities are living, breathing entities with emergent properties. They are characterized by unpredictability, adaptability, and a capacity to evolve in response to changing circumstances.

Understanding these aspects is vital for urban planners, policymakers, and researchers, underscoring the need for flexible and adaptive approaches to urban development [10]. It also emphasizes the role of local interaction and the importance of harnessing the inherent capacity of cities to self-organize for sustainable and resilient urban futures. It also suggests that emerging trends in urban settlement formation are driven by the growing global population and the need for more sustainable and controlled urban growth. [11] Sustainable development, defined as "Meeting the needs of the present without compromising the ability of future generations to meet their own needs," encapsulates the fundamental principle of sustainability, emphasizing a balance between current and future well-being [12]. This definition underlines the interconnected nature of environmental, social, and economic aspects in achieving sustainability, as shown in (fig.1), particularly in informal areas, as a means to enhance sustainable development. However, to achieve sustainable urban upgrading, it is imperative to foster an economic environment conducive to sustainable development, improve the efficiency and responsiveness of governmental agencies, facilitate democratic political systems, safeguard both the environment and vulnerable populations, narrow the gap between socioeconomic classes, encourage active community participation and promote cultural and social integration and diversity [13]. These measures collectively create resilient, equitable, and environmentally responsible urban environments. Sustainable development involves a series of interconnected actions that aim to achieve significant objectives with a strategic focus on the future [14]. The table below (Table1) and (fig.2) illustrate key points in sustainability and its description.

Fig. 1: The Contributors to Achieve Sustainability
Source: Author

Table 1: key points in sustainability and its description

key points in sustainability	Description	Ref.
Sequential Process	Sustainable upgrading is depicted as a sequential series of actions linked together in progression. Each step leads to the next, aiming to attain significant sustainability goals. This implies that sustainable development is not a singular occurrence but an enduring and developing endeavor.	[15]
The conflict between Ecology, Economy and Equity	A potential conflict arises among three essential sustainability dimensions: ecology (environmental concerns), economy (financial and economic factors), and equity (social justice and inclusivity). Finding equilibrium among these facets poses challenges, as actions benefiting one aspect may inadvertently impact the others. For instance, prioritizing economic growth might occasionally conflict with environmental preservation or social fairness.	[16]

Integrated Sustainability	The ultimate objective is to achieve comprehensive sustainability within urban settings, which entails harmonizing the interests of property development, urban growth, and resource management. By striking a harmonious balance among these elements, cities can enhance their profitability, equity, and environmental responsibility.	[17]
Profitability, Equity, and Environmental Responsibility	Striking harmony among property concerns, urban expansion, and resource stewardship results in cities that are not only economically viable, fair, and environmentally conscious but also benefit city governance, stakeholders, and developers alike.	[18]

Source: Author based on all the above references

Fig. 2: key points in sustainability and its description
Source: Author

Sustainable urban planning is essential for creating cities and urban areas that are environmentally responsible, economically viable, and socially inclusive [1]. Several approaches and strategies are used in sustainable urban planning. The following figure (Fig. 3) illustrates them.

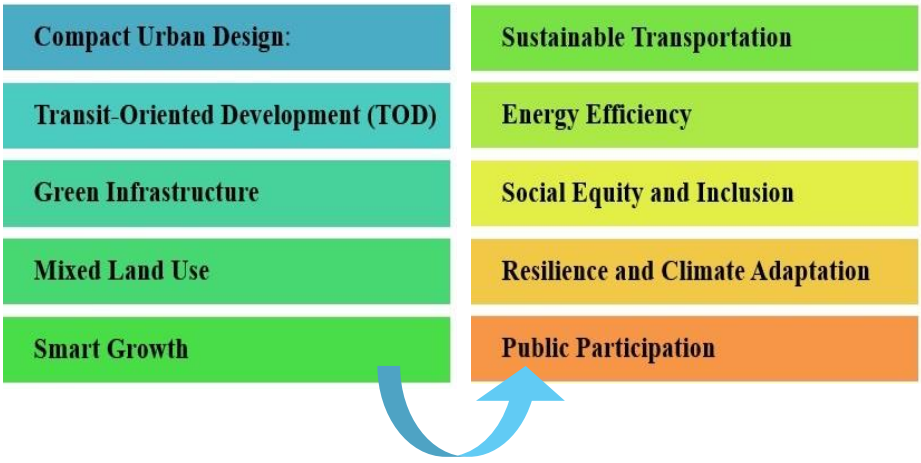

Fig. 3: The approaches and strategies used in sustainable urban planning.
Source: Author

4. Case study

4.1. Curitiba – Brazil

Curitiba is the capital city of the Brazilian state of Paraná, It is located in the southern region of Brazil, approximately 934 kilometers southwest of São Paulo, Brazil's largest city. The city is bordered by

the municipalities of Almirante Tamandaré, Colombo, Pinhais, and São José dos Pinhais. Additionally, Curitiba is situated near the Atlantic coast, providing easy access to nearby coastal cities such as Paranaguá and Pontal do Paraná.as shown in (fig.4). It was initially founded in 1530 as a gold mining camp and officially became a city in 1812. It is situated approximately 932 meters above sea level. Curitiba has experienced sustained rapid economic and population growth since the 1940s. In the early 1970s, the city underwent a significant renovation, which involved the design of new lakes and flood-control systems, large parks, and other amenities. Additionally, Curitiba implemented recycling programs, zoning guidelines, and specified bus services, establishing itself as a model of environmentally conscious urban planning [19].

The pivotal role of Jaime Lerner in Curitiba's urban development is significant, and it exemplifies how visionary leadership can drive positive change in a city. In (table 2) some key points regarding Jaime Lerner's influence on Curitiba's development [20].

Fig. 4: Curitiba city in the Brazilian state
Source: [21, 22]

Table 2: key points regarding Jaime Lerner's influence on Curitiba's development and the city's reputation

	key points on Curitiba's development	Ref.
Model for Urban Planning	Curitiba is often regarded as a model for urban planning and sustainable development. Under Lerner's guidance, the city implemented innovative and forward-thinking urban solutions, which garnered international attention and recognition.	[19]
Excellence in Public Transportation	One of Curitiba's most notable achievements is its world-renowned bus rapid transit (BRT) system. This efficient and sustainable Public Transportation network has become a benchmark for other cities seeking solutions to traffic congestion and pollution.	[23]
Ecological Capital of Brazil	Curitiba's dedication to green spaces and environmental sustainability has earned it the "ecological capital of Brazil." The city's commitment to preserving and expanding green areas has contributed to its reputation as an environmentally conscious urban centre.	[24]
Urban Enhancements	Curitiba's efforts have included urban enhancements like improving walkways and roadways, restoring historic buildings, and creating new parks. These improvements not only contribute to residents' quality of life but also a sense of pride and belonging.	[14]
Attracting International Attention	Curitiba's urban innovations have attracted urban planners, policymakers, and the international media. Other developing countries often look to Curitiba as a source of inspiration and guidance in addressing urban challenges.	[19]

Source: Author based on all the above references

4.2. Curitiba`s history

In the following table (table 3), you will see a glimpse into Curitiba's historical development, geographical location, and role as a significant urban center in Paraná, Brazil. It sets the stage for

understanding the city's growth and transformation into a model of sustainable urban development and planning [25].

Table 3: Curitiba's historical development and its geographical location

Year	Development	Ref.
1943	A French urban planner, Alfred Agache, developed the Agache Plan. One of the main scenarios within Agache's plan was the full motorization of the city's "grand boulevards radiating from the central core," where it was essential to accommodate the increases expected in vehicle tracks.	[26]
1965	Jaime Lerner, appointed mayor of Curitiba, played a pivotal role in implementing the Master Plan, drawing upon the expertise gained from his involvement with the Curitiba Research and Urban Planning Institute (CRUPI). In response to the city's developmental needs, civic leaders facilitated a competition among local architects and planners to propose plans for Curitiba's future growth.	[25]
1968	After adopting Curitiba's Master Plan, the city has implemented innovative systems aimed at job creation, enhancing accessibility to public transportation, fostering housing development, and improving waste management. The city has adopted a "radial linear-branching pattern" to preserve density by redirecting traffic away from the city center and safeguarding green areas by promoting industrial development along radial axes. Additionally, Curitiba has introduced a "Bus Rapid Transit System" and established the CIC (Curitiba Industrial City) on the western side of the city, which enforces stringent environmental regulations and prohibits "polluting" industries.	[23]
2004	After Forty years of pedestrian and TOD "transit-oriented growth," " the city has seen an increase in the number of users on bus and express lines. Their three guiding principles for the Master Plan were preserving the guidelines established by the Master Plan, merging important urban policies for the city, and implementing new urban tools.	[23]
2010	Curitiba received the "Globe Sustainable City Award," highlighting the city's innovative approach to urban planning and sustainability.	[26]

Source: Author based on all the above references

4.3. Curitiba's approach to urban planning and sustainability

Curitiba's approach to urban planning and sustainability serves as a model for other cities. It demonstrates how a combination of integrated planning, public engagement, and innovative solutions can create a more livable, efficient, and sustainable urban environment while fostering a strong sense of community and belonging among residents [27]. as shown in (table 4).

Table 4: Curitiba's approach to urban planning and sustainability

The urban planning process of Curitiba		Benefit	Ref.
Integrated Master Plan	Transportation and land use planning	A more coordinated and sustainable approach to urban development	[8]
Pedestrian-Friendly Downtown	Curitiba partially closed its downtown to vehicles and created pedestrian streets.	Enhance the quality of life in the city centre and promote walkability.	[28]
Mixed Land Use and High-Density Residential Buildings	Mixed land use along transportation axes, accompanied by high-density residential buildings.	Promoting compact, walkable neighborhoods and making public transportation easily accessible.	[23]
Linear Development Along Arterial Roads	Linear development along arterial roads	Reduces the need to enter the city centre and creates opportunities for light industries and commercial activities near efficient transportation access points.	[1]
New Industrial City and Low-Income Housing	The development of a new industrial city near the	Reflects commitment to social inclusivity and economic	[23]

	seashore, including low-income public housing	development in different parts of the city.	
Public Participation	The city incentivizes low-income residents to use public transportation by exchanging waste collection for bus travel tokens	promoting both a cleaner environment and public transport usage.	[23]
Open Access to Information	The city offers access to data on every plot of land	Fostering transparency and enabling residents to have insights into city planning and development.	[17]
Community Participation for Trust and Belonging	Involving residents in the urban planning process is essential for building trust and a sense of belonging between citizens and the city's various stakeholders.	Ensures that development aligns with the community's needs and aspirations.	[8]

Source: Author based on all the above references

4.4. Effective public bus system of Curitiba & Evolution of the Integrated Transit network

Curitiba's public bus system, known as the Bus Rapid Transit (BRT) system, is widely recognized as one of the world's most efficient and sustainable urban transportation systems. These systems have improved accessibility, reduced congestion, and minimized the city's environmental footprint, making Curitiba a model for other cities seeking to enhance their public transportation and overall urban sustainability. The following (table 5) illustrates the features that make this system highly effective [23].

Table 5: Effective public bus system of Curitiba and its evolution

Bus system	Benefit	Evolution	Ref.
Exclusive Lanes for the BRT system	Help buses bypass traffic, making public transportation a competitive choice for commuters.	The city has adapted its infrastructure to streamline passenger flow and enhance the system's efficiency.	[23]
Frequent Service	Run at high frequencies, reducing waiting times for passengers.	The transit network has expanded to cover a broader city area and connect various .	[19]
Integrated Fare System	The city implemented a single, integrated fare system for public transportation.	No Evolution	[23]
High Passenger Capacity	BRT vehicles are designed to carry many passengers, allowing for efficient mass transit.	The integrated transit network encompasses multiple modes of transportation, including buses, trams, and pedestrian walkways.	[28]
Accessibility	Low-floor bus stations make it accessible to people with disabilities.	No Evolution	[23]
Land Use Planning	The BRT system is closely integrated with land use planning.	Integrating cleaner, more fuel-efficient buses, green corridors, and park spaces, considers land use planning.	[8]

Source: Author based on all the above references

4.5. Bikeways

Creating bikeways aims to construct a circuit to develop alternative non-polluting modes and build support structures for the cycling network, such as bicycle racks, public bike parking, bicycle racks at the bus station, and intermodal integration [29].

4.6. Parklets

The main concept of the parklets is temporary or permanent extensions of the sidewalk (public spaces) from the use of parking spaces. In addition, the main goal is to improve the quality aspects of urban expansion of pedestrian spaces, particularly the spaces for different public means of transportation. Moreover, the context within the metropolitan areas is divided into two parts: **first**, the Commercial area (improving the dynamics of local economic activity), and **second**, the Residential area (the improvement of residential ambiance) [28].

4.7. The environmental awareness

In the early 1970s, residents planted 1.5 million trees in the city streets to preserve and improve green areas and improve local environmental awareness. The city established the environmental and ecological information center and city botanical garden [16, 17].

4.8. Local waste management system

Seventy percent of the city's waste was recycled by residents in the "garbage that is not garbage" program. In addition, the garbage program "Green Exchange" concentrates on the environmental and social benefits. The innovative 'Purchase of Garbage' program lets low-income families living in areas that lack accessibility get their waste bags to centers of neighborhoods, where they exchange them for bus tickets, agricultural products, and food[21].

4.9. Natural disaster management

The development of projects to reduce the effect of significant rainfall caused by climate change along the water basing of the city was the main goal of the Natural disaster management program, through: Retarding structures and containment basins, De-naturalization of the valley bottom area and providing linear parks (Cycle paths, Outdoor gyms, Recreational area, Landscaping & Lighting projects) [29].

4.10. Pedestrian priority and heritage rehabilitation

The city center area was converted into a pedestrian public space with restaurants, shops, and cafes. Upgrading the area involved incorporating historical urban elements of Curitiba, such as a theater, shopping mall, cultural documentation service, creativity center, and museum [28].

4.11. The new challenges facing Curitiba Urban Development

Curitiba is confronting urban development challenges as sustainability hinges on three main aspects: social, economic, and environmental considerations, as shown in (fig. 5).

- **Environmental**: The BRT system has reduced carbon emissions [10].
- **Socioeconomic**: The population is more concentrated in the central areas, and there is a reduction in the low-income levels [9].
- **Economic:** The Industrial City Curitiba goal is to upgrade its financial profile and afford job opportunities for its residents. On the other hand, the BRT system has a good impact on Curitiba's economy, like increasing fuel efficiency, reducing transit, and decreasing auto trips due to the development of transit-supportive land uses and decreased household motorization rates [23].

Fig. 5: The three main aspects of Sustainability in Curitiba
Source: Author

5. Results

James Learner, the mayor of Curitiba, implemented the master plan vision in the early 70s to transform Curitiba into a sustainable, green city. This successful plan was not only about transportation but also waste management, urban design, and Curitiba residents' quality of life. On the other hand, the implemented model of BRT is one of the successful models of urban planning in Latin America, and nowadays, it is used in fifty-six cities in Latin America. The residents of Curitiba are heavily involved in good waste management practices and are continuously encouraged by the administration to recycle their waste. Moreover, a combination of the strategies will be necessary in any modern development plan. It is hoped that governments can create initiatives to ensure the implementation of housing solutions will be more direct and controllable, allowing developments to be made where they are needed, in the quantity required, and with the appropriate quality, affordability, and sustainability. The Bus Rapid Transit (BRT) system offers several advantages and disadvantages, making it a complex solution that requires careful consideration in urban planning. The following table (table 6) illustrates an overview of the advantages and disadvantages of the BRT system.

Table 6: The Advantages and Disadvantages of BRT

Advantages of BRT	Disadvantages of BRT
Cost-Effective: BRT systems are generally more cost-effective than traditional rail-based transit systems, making them a practical option for many cities.	**Limited Capacity in the Long Term:** While BRT can handle substantial passenger loads, it may not be sufficient for the long-term capacity needs of rapidly growing cities with extremely high population densities.
Rapid Implementation: BRT systems can be implemented more quickly than rail-based systems. They offer a relatively swift solution to address transportation challenges.	**Congestion on Mixed Traffic Segments**: BRT systems may operate in mixed traffic in certain sections, resulting in congestion and delays during peak hours.
High Capacity: BRT vehicles, such as articulated buses, can carry many passengers, making them suitable for high-density urban areas.	**Infrastructure Requirements**: While BRT systems are generally cost-effective, creating dedicated lanes and high-quality stations can still be a significant investment.
Dedicated Lanes: BRT systems often feature dedicated bus lanes, reducing congestion and ensuring faster travel times, which is attractive to commuters.	**Limited Network Flexibility:** BRT networks are constrained by road infrastructure. Expanding the network or adapting to changing demands can be challenging.

Efficiency: BRT systems offer efficient transportation, with features like frequent service, level boarding, and transit signal priority to reduce waiting and travel times.	**Perceived Image:** Some people may perceive buses as a less attractive mode of transportation than rail, impacting ridership and public perception.
Flexibility: BRT systems are adaptable and can be modified to meet changing transportation needs as a city grows and evolves.	**Maintenance and Operational Costs:** Operating and maintaining BRT infrastructure and vehicles can be expensive, and keeping lanes dedicated can be significant.
Environmental Benefits: BRT systems can help reduce traffic congestion and air pollution by encouraging public transportation and reducing the number of private vehicles on the road.	**Environmental Impact:** BRT systems can be more environmentally friendly than personal vehicles, but they still rely on fossil fuels, contributing to carbon emissions.
Integrated Land Use: BRT systems often integrate with land use planning, promoting transit-oriented development (TOD) and high-density development along transit corridors.	**Complex Implementation:** Implementing a BRT system can be complex and may require changes to road layouts, station construction, and traffic management, leading to potential disruptions during the implementation phase.

Source: Author

The effectiveness of a BRT system depends on various factors, including the specific needs and context of the city. BRT systems can provide an efficient and sustainable solution to urban transportation challenges when well-planned and executed. However, they may not be the best fit for all urban environments, and a thorough analysis is required to determine their suitability.

Urban morphology is not an end-state but a dynamic process influenced by various forces. It serves as a functioning regulator, aiming to achieve specific objectives through its orientation. Additionally, urban morphology is a crucial determinant of urban patterns, forms, and spatial components, intricately woven into the fabric of urban spaces. While urban form and structure encompass diverse physical and spatial elements, urban morphology delves deeper into understanding the interplay between these elements and the social forces driving them. Moreover, it explores the differentiation of urban morphological approaches across different urban spaces, highlighting the nuanced adaptations required to address specific contextual factors.

Urban morphological analysis hinges on three fundamental components, as shown in (fig. 6). **Firstly**, the form of the urban environment is shaped by three primary physical elements: buildings and associated open spaces, building lots or parcels, and streets. These elements interact dynamically to shape the form and structure of the urban environment. For example, the layout of streets and the distribution of building lots determine the spatial organization of the city, while buildings and open spaces contribute to its aesthetic and functional qualities. **Secondly**, the resolution of urban form can be examined at four distinct levels, ranging from the building/lot scale to the regional scale, encompassing streets, blocks, cities, and regions. By analyzing urban form at multiple scales, it becomes possible to understand the interconnectedness of various elements and processes shaping the city's physical structure. **Lastly**, time is a crucial dimension in understanding urban form, as it undergoes continuous transformation and replacement, necessitating a temporal perspective to grasp its evolution accurately. Over time, buildings are constructed, modified, or demolished, streets are expanded or reconfigured, and open spaces are created or repurposed. A temporal perspective is essential for understanding these changes and their implications for the city's evolution. By examining urban form over time, planners and policymakers in Curitiba can identify trends, anticipate future challenges, and make informed decisions to shape the city's future development in a sustainable and resilient manner.

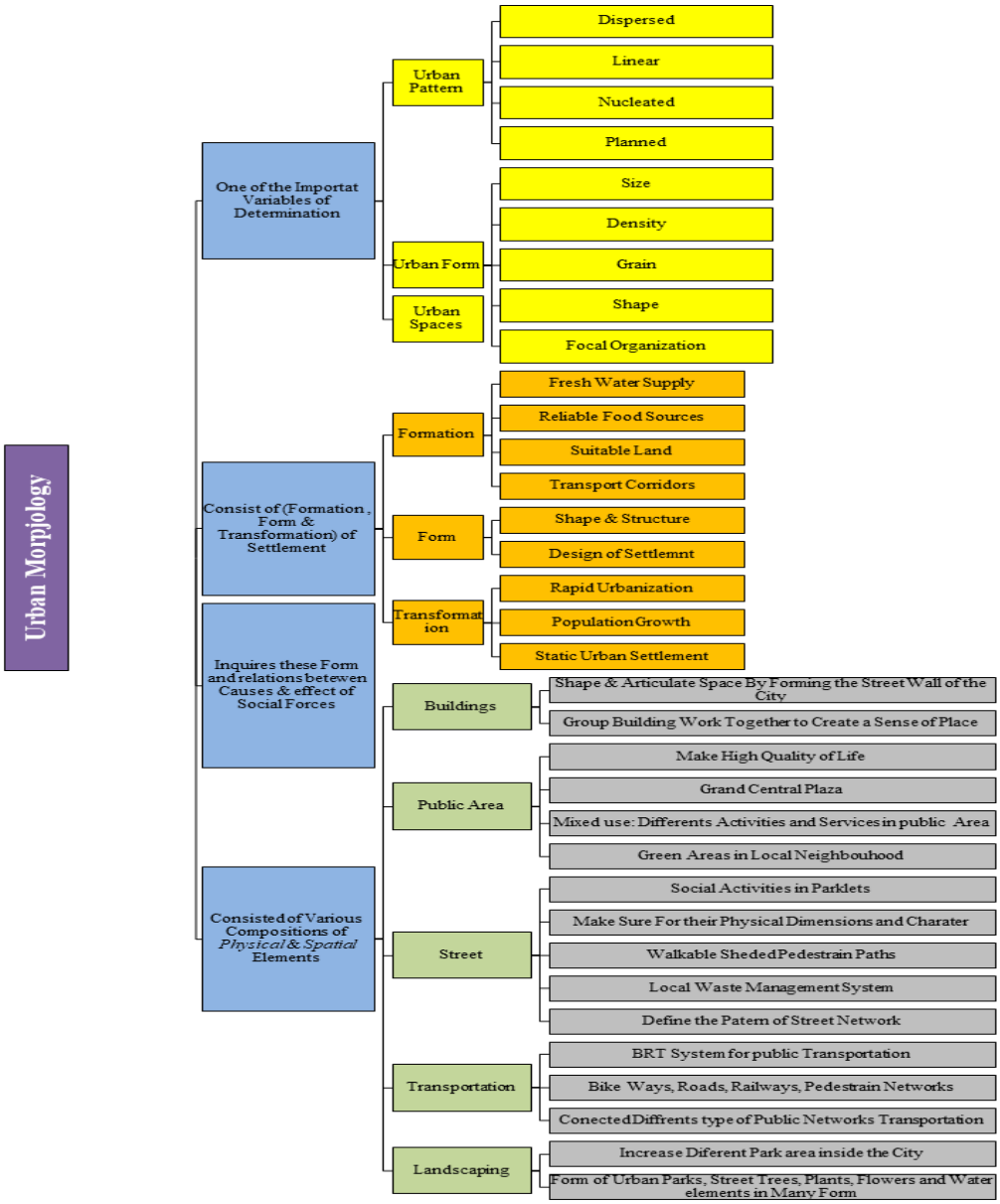

Fig.6: The three fundamental components help deal with urban morphology. Source: Author

6. Discussion/Conclusion

The effectiveness of a Bus Rapid Transit (BRT) system depends on various factors, including the specific needs and context of the city. BRT systems can provide an efficient and sustainable solution to urban transportation challenges when well-planned and executed. However, they may not be the best fit for all urban environments, and a thorough analysis is required to determine their suitability of BRT systems within specific urban environments, considering factors such as population density, existing transportation infrastructure, and socio-economic dynamics. Moreover, a critical examination of the literature reveals nuanced insights into the advantages and limitations of BRT systems, shedding light on their performance across diverse urban settings. In conclusion, this research underscores the critical role of urban morphology in addressing the challenges of rapid urbanization and climate change. By prioritizing sustainability in urban design and planning, cities can create more livable, environmentally responsible, and socially inclusive environments. The findings of this research contribute to the ongoing discourse on sustainable urban development, emphasizing the need for integrated approaches that consider the multifaceted nature of urban morphology and its implications for sustainability. In this regard, the insights gleaned from Curitiba provide valuable guidance for addressing urban challenges across different cultural, economic, and

political contexts. For instance, Curitiba's success in implementing sustainable transportation solutions, like the Bus Rapid Transit (BRT) system, highlights the importance of innovative urban planning approaches that prioritize public transit and non-motorized transportation modes. This strategy could be adapted by cities facing similar transportation challenges, promoting more efficient and eco-friendly mobility options. Furthermore, Curitiba's focus on green spaces and integrated urban development offers valuable lessons for urban planners elsewhere, demonstrating the benefits of preserving and enhancing natural areas within city environments. Additionally, Curitiba's participatory decision-making processes could serve as a blueprint for fostering community involvement and empowerment in urban governance, encouraging residents to actively contribute to shaping their cities' futures. However, it's important to recognize that applying Curitiba's experiences to other cities may require adjustments to accommodate local cultural norms, economic circumstances, and political frameworks. Therefore, while drawing inspiration from Curitiba, policymakers and urban planners should tailor strategies to meet the specific needs and characteristics of each urban setting, ensuring that sustainable development efforts are both contextually appropriate and socially inclusive, finaly the research conclude the approaches and strategies utilized in sustainable urban planning by examining Curitiba as a model for sustainable cities, as shown in the table(7) , Future research endeavors should aim to conduct comparative analyses across multiple cities and incorporate a broader range of variables to enhance the robustness and generalizability of the findings.

Table 7: The approaches and strategies utilized in sustainable urban planning

urban challenges and promote sustainable development		Results
Compact Urban Design	Reducing urban sprawl and efficient use of land.	• Encourages higher population densities • Reduces the need for long-distance travel • Fosters a sense of community
Transit-Oriented Development (TOD)	Integrate TOD principles into urban planning	• Encouraging walking and cycling • Encouraging the use of public transportation.
Green Infrastructure	Prioritizes the preservation and enhancement of green spaces, parks, and urban forests.	• Improved air quality • Stormwater management • Biodiversity conservation.
Mixed Land Use	Encouraging the coexistence of residential, commercial, and recreational activities within neighborhoods.	• Reduce the need for vehicular travel • Enhances walkability
Smart Growth	Revitalizing existing urban areas, and promoting sustainable land-use patterns.	• Minimizes urban sprawl • Optimizes infrastructure investments • Enhances the quality of life for residents.
Sustainable Transportation	BRT system is a hallmark of sustainable transportation	• Provide fast, affordable, and efficient transit options for residents.
Energy Efficiency	Implement various energy-efficient initiatives	• Save energy consumption
Social Equity and Inclusion	All residents have access to essential services, affordable housing, and public amenities.	• Reduce socioeconomic disparities • Fosters social cohesion.
Resilience and Climate Adaptation	Mitigate the impacts of climate change and natural disasters.	• Enhance the city's resilience to environmental risks.
Public Participation	Public consultations, community workshops, and citizen advisory committees.	• Empowers residents to contribute their insights and perspectives • Fostering a sense of ownership and accountability in shaping the city's future.

Source: Author

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