Creating Self-Supportive and Sustainable Urban Districts to Minimize Traffic Congestion.

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Abstract

This research aims to explore the intersection of state policies, urban planning, and architecture in creating self-supportive, adaptive, and green environments for urban districts or zones to minimize traffic congestion. The objective is to propose effective strategies that enable people to live within walking distance of their workplaces and essential amenities, thereby reducing travel time and promoting sustainable urban development. The study anticipates that the implementation of self-supportive districts will have several positive outcomes. These include minimized traffic congestion, reduced travel time, decreased air pollution and carbon footprint, improved road safety, and enhanced quality of life for urban residents. This research highlights the significance of integrating state policies, urban planning, and architecture to address traffic congestion in urban areas. By creating self-supportive and sustainable districts, cities can effectively minimize traffic congestion, enhance livability, and contribute to a greener and more sustainable future.

Keywords: Traffic congestion, Self-supportive districts, Sustainable urban planning, Travel time, Green environments.

1. Introduction

According to (*Global Commuter Index-Moneybarn,* 2023), some might take their daily commute as simple but it affects our well being both physically and mentally while reduction in transport cost offers greater financial stability. According to (Workers, 2023), long hours of commuting, is associated with, high blood pressure, increased anger and resentment at work and can also increase the risk of heart attacks, flu, depression etc.

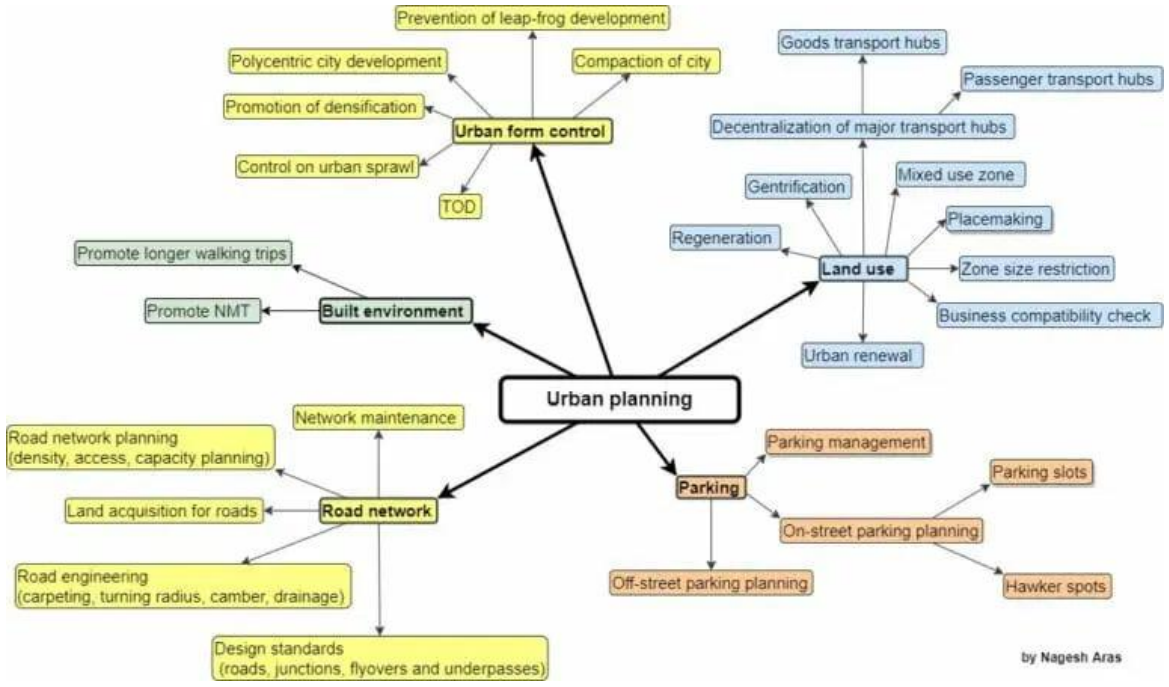
Traffic congestion makes a city gradually dead. Researchers and Planers are continuously trying to solve the problem of congestion. This paper will show how any mega city could mitigate traffic congestion by creating self-supportive urban districts that enable people to live in the nearby housing within walking distance of their workplaces and essential amenities as well as developing policies to make those urban areas or districts expandable and adaptive in a sense when relocation or transfer of people, workplaces, amenities and housing would be necessary. But while these self-supporting and adaptive urban districts will be easy to create in vacant areas, whereas very difficult to revitalize existing urban districts in cities. Still this paper will provide some policies and guidelines for such revitalization.

1.1 Literature review

Analyzing 27 factors that are contributing directly or indirectly to congestion, (Rahman et al., 2021), shows that, population size, per capita income, and employment concentration increase traffic congestion. Noting the mutual connection between land use and transportation, more efficient land-use management has been advocated to reduce congestion (Chen & Chang, 2014). Sustainable urban forms (e.g., compact development, eco-city, smart growth) reduce traffic congestion by changing the travel behaviors of people, bringing workplaces and amenities closer together (Babalik-Sutcliffe, 2013).

Compact development (i.e., high density, mixed land use) reduces travel demand and congestion by agglomerating urban activities and substituting auto trips with walking/cycling trips. Similarly, compact land use pattern (i.e., housing-job proximity) reduces work trip length and thereby reduces travel delay (Sarzynski et al., 2006). According to (Aras, 2022), "Half the battle is won when a city is well-planned to carry its traffic. City planners must take measures that control and change the shape of the city itself, by controlling the urban form, land use and design of individual neighborhoods (para. 2)." Following figure depicts some Urban planning measures to reduce congestion suggested by (Aras, 2022):

Figure 1: Urban planning measures



Source: Graphic by Nagesh Aras: https://citizenmatters.in/urban-planning-measures-for-mobility-commute-roads-parking-land-use-30901

But how the above high density mix-use compact developments will cope or adapt with our socio-ecoomic behavior in choosing workplace and residence or with the transfer and relocation of business, amenities and people and implementing these on existing built forms is a challenge. Further how we could create co2 free neighborhood fol all citizens is crucial too. This research paper will address these gaps to make the carbon and congestion free self-supportive as well the adaptive green sustainable urban districts and city.

To control population density, FAR or floor area ratio is applied to the city blocks or districts. But it's noteworthy that, lower FAR value for any district will prevent the compact vertical development to

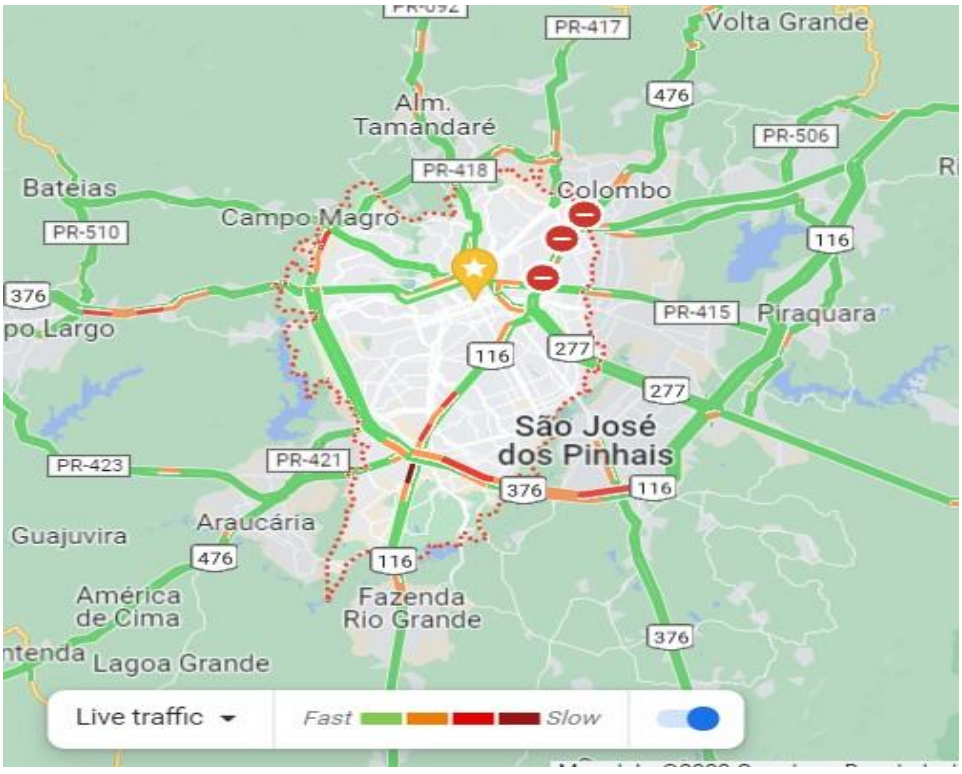
accommodate more people specially in a densely populated city as well insist to encroach more farmland or natural land as urban sprawls. (Aras, 2022), stated that "When the population is thinly spread out over a vast area, it is too expensive to provide public transport to such areas (para. 10)."

To formulate a workflow to make a self-supportive urban district and a green city, this paper also reviewed three case studies. One of the best example of Transport Oriented development is Curitiba, Brazil, which was within top 5 cities with lowest congestion rate in 2022.

Curitiba, Brazil:

Curitiba has suffered from all the typical problems brought by rapid urban growth: mass unemployment, transport congestion, lack of basic services and uncontrolled growth of squatter settlements (Wheeler, n.d.). However, the city has been redesigned and efficient public transit systems present a greener and cleaner solution for mass movement in densely populated urban regions (Cavalcanti et al., 2017), (Moore, 2007). Buses and trains reduce the number of individually occupied vehicles on the road, therefore reducing traffic and the city's overall fuel consumption and carbon emissions (Barczak and Duarte, 2012).

Figure 2: Google map of Curitiba, Brazil showing traffic condition in roads.



Source: https://www.google.com/maps/place/Curitiba,+State+of+Paran%C3%A1,+Brazil

Figure 3: Bus Rapid Transit in Curitiba, Brazil.

Source: By Mario Roberto Duran Ortiz Mariordo - Own work, CC BY 3.0, https://commons.wikimedia.org/w/index.php?curid=3569683

Lagos, Nigeria:

Lagos is the mostly congested city in the world in 2023. According to (Adefaka, 2017), "Simply put, the major causes of traffic congestion in Lagos metropolis are bad road, inadequate road infrastructure, accident, inadequate traffic planning, drivers' behavior and lack of integrated transport system. (para. 21)."

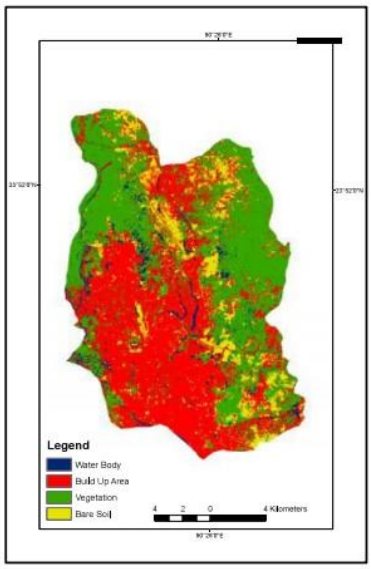
Figure 4: Traffic congestion in Lagos

Source:https://nigeriarealestatehub.com/problem-traffic-congestion-lagos/

Dhaka, Bangladesh:

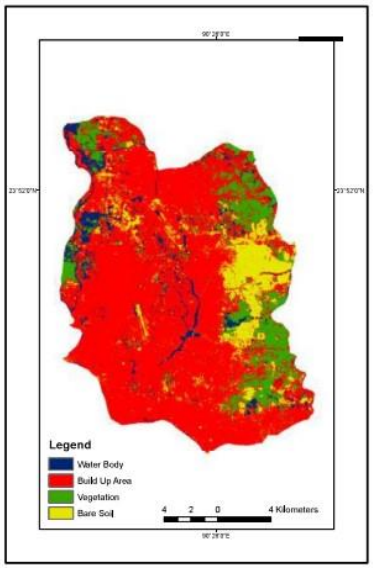
According to (Rahman, 2022), “In the last 20 years, the built-up area of Dhaka has risen dramatically. At the same time, the city of Dhaka's population has grown. The quantity of built area has expanded to accommodate a big number of people in this city, posing a threat to Dhaka (p. 8).”

Figure 5: Land use/land cover map of 2001



Source:Rahman, (2022)

Figure 6:Land use/land cover map of 2021



Source:Rahman, (2022)

Policies study:

Governing urban policies makes a big difference as we see, in the case of Curitiba, Brazil. According to the (Wikipedia Contributors, 2019), an architect named Jaime Lerner, suggested strict controls on urban sprawl, as well reduced traffic in the downtown area, and implemented an affordable public transit system.

But unfortunately, regulatory processes of urban planning for Lagos and Dhaka is poor. For Lagos, (Fagbe et al., 2020), described government inefficiency in managing congestion as "..the terrible state of the road that arose from lack of government sincerity in driving national economy via road infrastructural development and lack of continuity in governing the system (p. 42)."

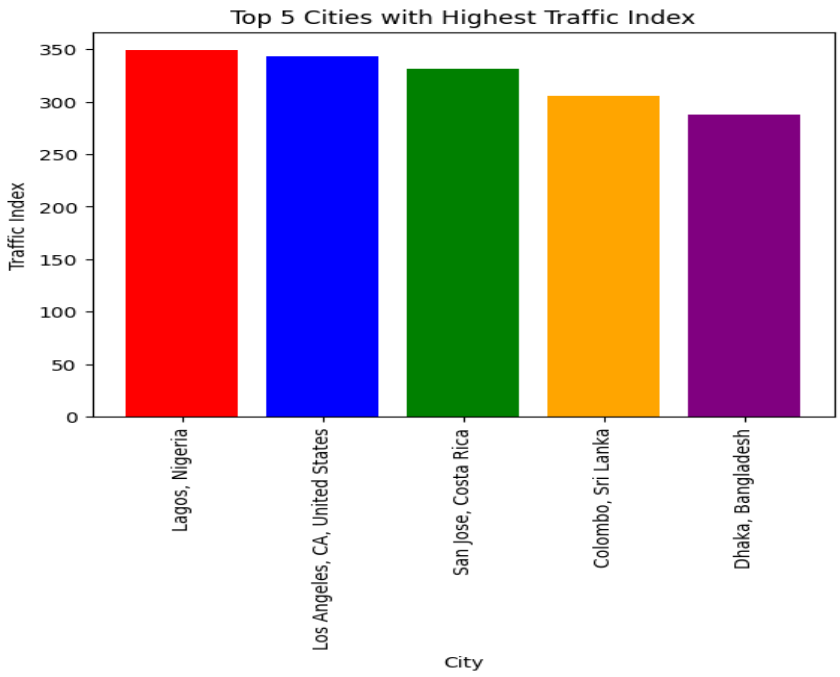
In case of Dhaka, (Afroz, n.d.) described the institutionalized corruption of planning authorities, "Enormous gaps have been identified in legal and institutional framework, which facilitated 'opportunities' for perpetrators to institutionalize corruption instead of governance (para. 4)."

2. Data and study methods

To create self-supportive, adaptive, and green environments for urban districts or zones to minimize traffic congestion, data were collected from secondary sources like from various online population census, urban planning reports, traffic index, policies and guidelines, data archives. Various python libraries like pandas, pandasai, numpy, AI imagery tools etc, were used for data analysis and visualization.

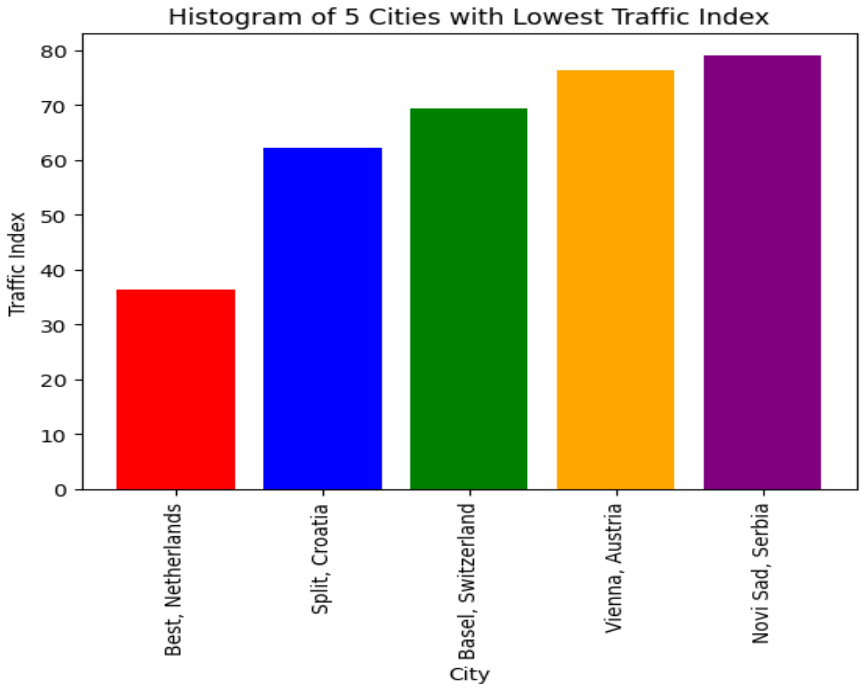
According to (*Traffic Index by City,* 2023) data, top 5 cities with Highest and top 5 with Lowest TI:

Figure 7: Top 5 congested cities with highest traffic index.



Source: Software generated diagram

Figure 8: Top 5 least congested cities with lowest traffic index.



Source: Software generated diagram

According to the (*World Population Dataset*, 2019), population growth rate of the top 5 five cities with the highest TI are:

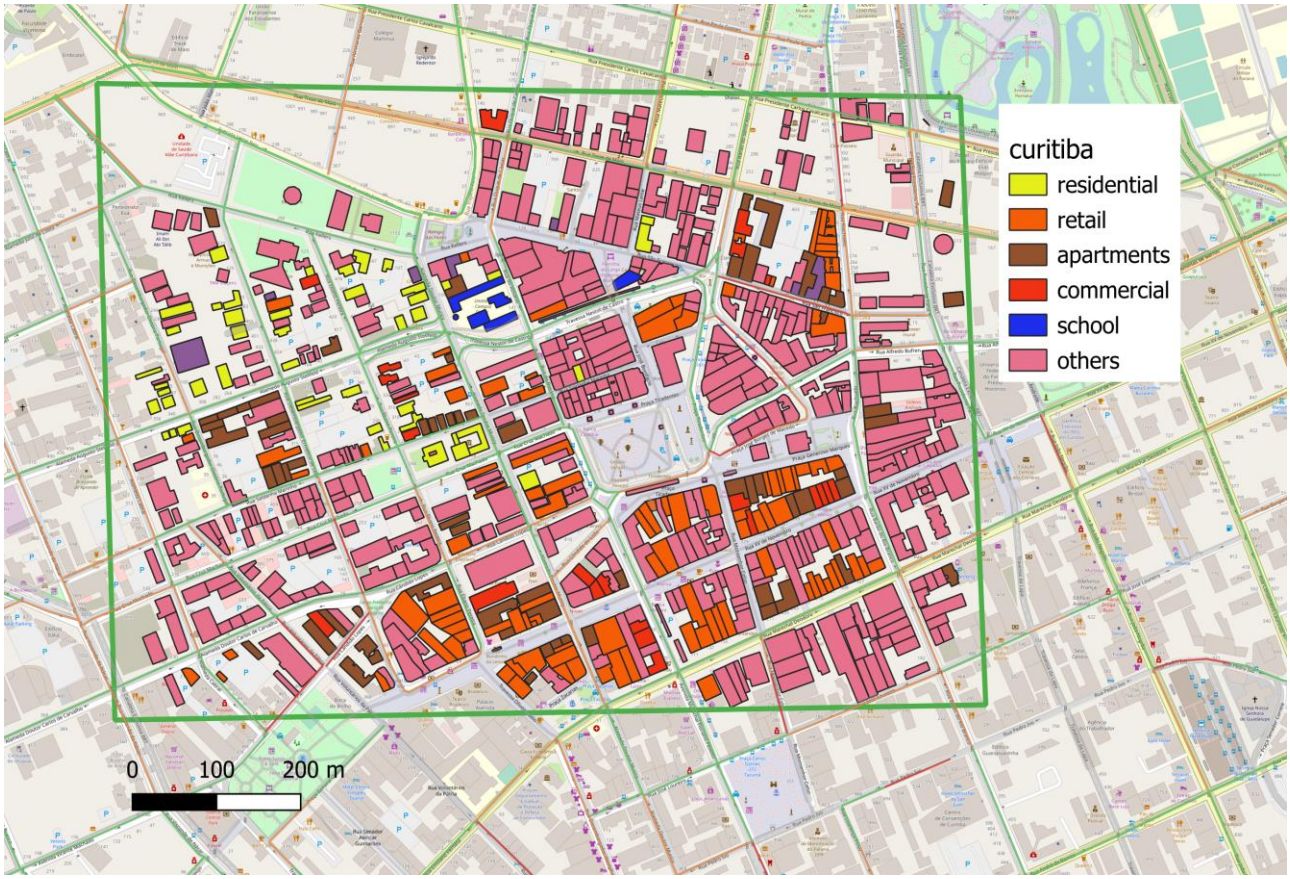
Figure 9: Top 5 highest congested cities with population growth rate.

City	Country	2023 Population	2022 Population	Growth Rate
Dhaka	Bangladesh	23209616	22478116	3.25%
Lagos	Nigeria	15945912	15387639	3.63%
Los Angeles	United States	3769485	3809182	-1.04%
San Jose	Costa Rica	1461989	1441324	1.43%
Colombo	Sri Lanka	21893579	21832143	0.28%

Source: Software generated diagram

QGIS 3.2 Lima was used to know the land use pattern of small areas of Curitiba, Lagos and Dhaka. Data were collected from (*Google Maps*, 2023) and (*Openstreetmap*, 2023) maps of (*Curitiba State of Paraná Brazil*, 2023), (*Lagos*, 2023), (*Dhaka*, 2023). Queries were run in (*Openstreetmap*, 2023) and (*Overpass-Turbo*, 2023) to get land uses. The data were then imported into QGIS. Traffic data from Google hybrid map had been juxtaposed. Sketchup pro 2022 and a plugin Modelur is used in modeling of SSUD.

Figure 10: Land use pattern and traffic of study area, Curitiba, Brazil.

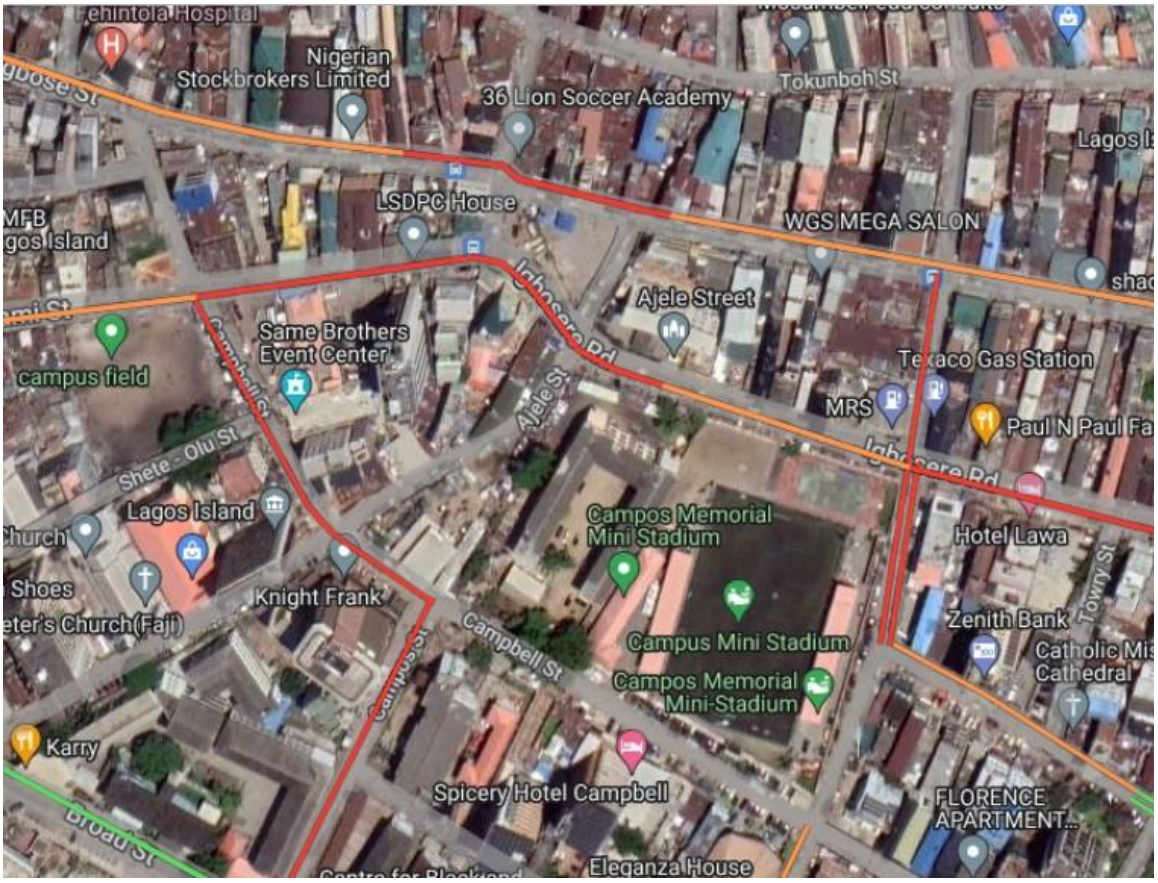


Source: Software generated diagram

Figure 11: 3d mass of study area, Curitiba, Brazil.

Source: Software generated diagram

Figure 12:Land use pattern and traffic of study area, Lagos, Nigeria.

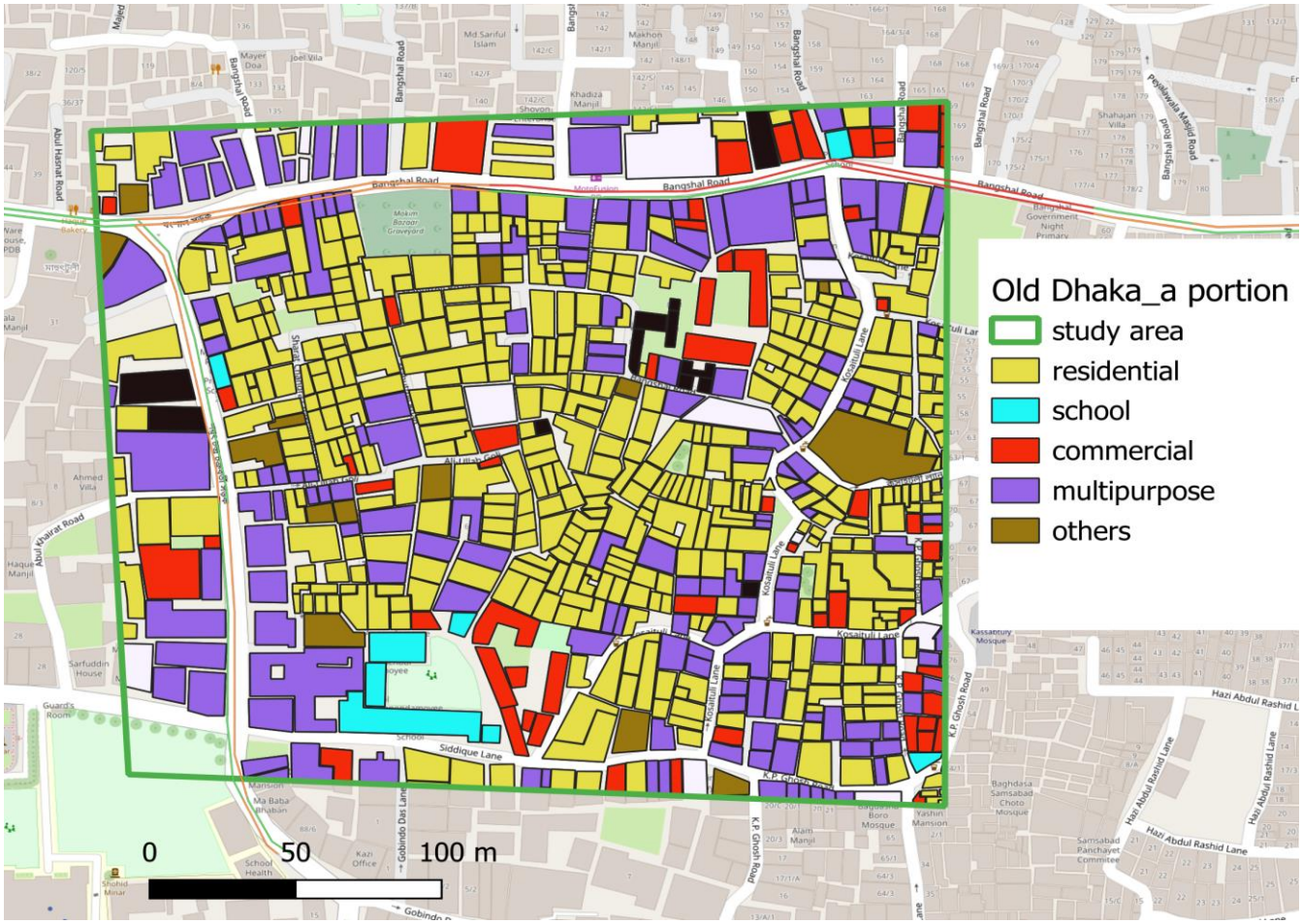


Source: Software generated diagram

Figure 13:3d mass of study area, Lagos, Nigeria.

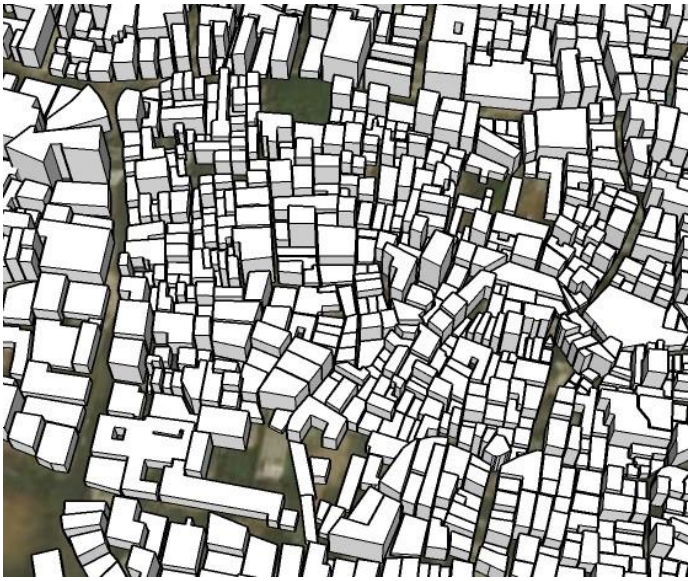
Source: Software generated diagram

Figure 14:Land use pattern and traffic of study area, Dhaka, Bangladesh.



Source: Software generated diagram

Figure 15:3d mass of study area, Dhaka, Bangladesh.



Source: Software generated diagram

Results and Discussion

From the study, population growth rate is high for Dhaka and Lagos, a major cause of congestion. From the land use pattern, we saw that, all the segments of 3 cities consists of mix-use developments but they are randomly placed and increasing the effects of congestion and co2 emissions. In Curitiba, the effect is lessened by the well planned public transport and strict control on land use whereas Dhaka and Lagos could not maintain it as shown by the Google traffic.

From the above Literature review and studies and analyses, this paper at first developed a fictional Self-Supportive and Sustainable Urban District and a fictional green city model. Then it tried to implement these models on three study areas.

Self-Supportive and Sustainable Urban District or SSUD model:

As already mentioned and discussed and from the studies, a fictional Self-Supportive and Sustainable Urban District should have the following characteristics but not limited to:

1. It would have a core residential area and commercial or amenities at the periphery.

2. Any type of commerce or educational and health facilities etc. amenities should be placed at periphery of the district. The peripheral commercial area must satisfy all their parking as well all the necessary parking for the core residential area and would be segregated by a green buffer.

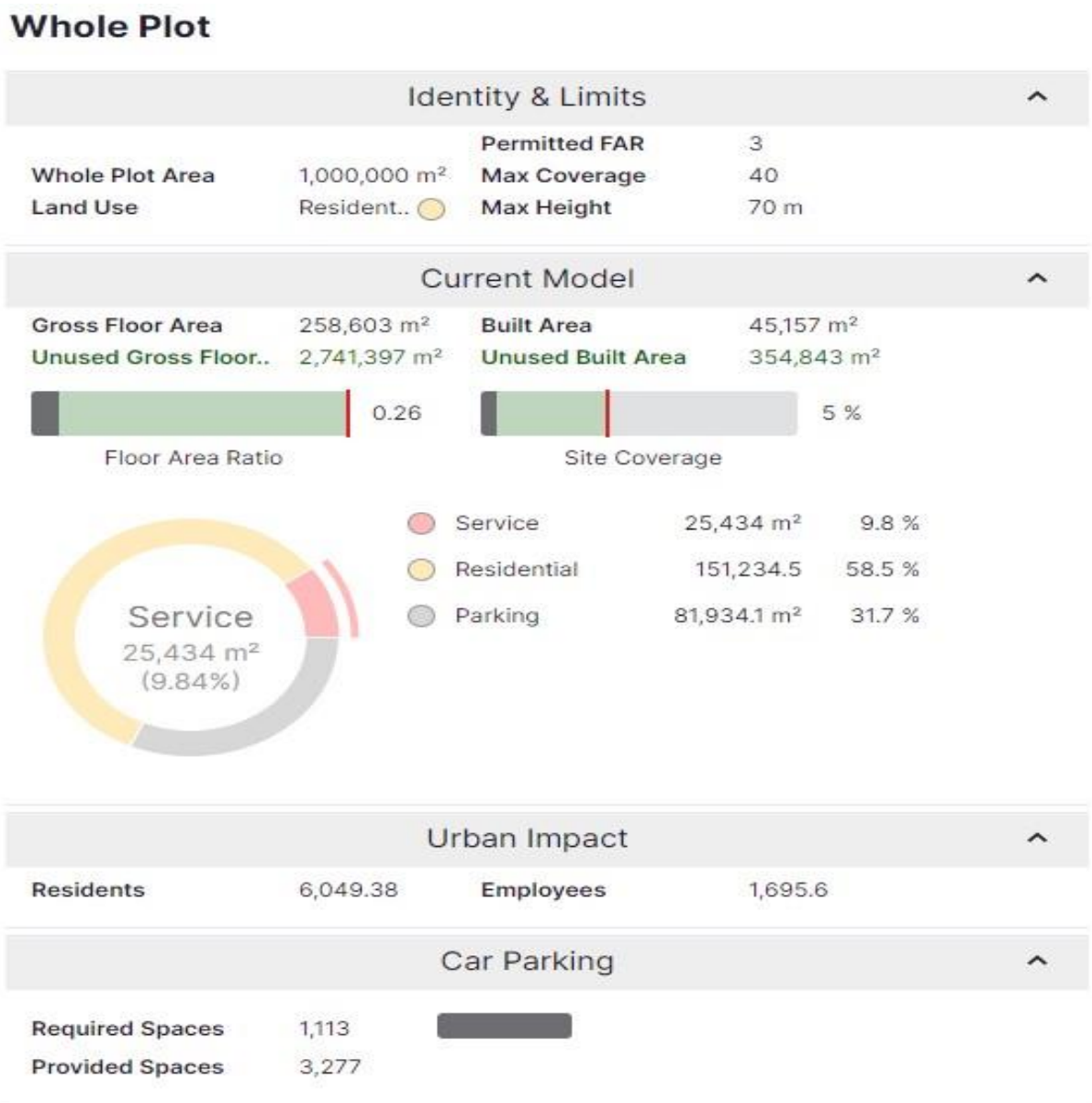
3. The residents of the district are none other than the owners and employees of the peripheral commercial establishments and should be reached by 10 minutes walking distance from the far end of the residential area.

Figure 16: Conceptual model of SSUD.

Source: Software generated diagram

SSUD statistics: With a FAR value of 3.00 and building height 70 m within an area of 1000mx1000m or 1 sqkm city block, approximately 6000 people could reside and 1500 of them will use commercial entities at periphery. By increasing FAR and building height, we can house more people in the same area. Though population density will be much higher than the globally excepted standard, 62 per sqkm, still its a dogma for world, either to vanish farmlands or forests or to increase population density in cities.

Figure 17: Data of a conceptual SSUD



Source: Software generated data

4. The core residential area having small parks, water bodies or public swimming pool should be car and vehicle free and its roads will be only for pedestrians and bikes to make it carbon free. But some electric or clean energy vehicles and small shops will be always allowed in the neighborhood for convenience.

Figure 18: Concept imagery of SSUD

Source: Software generated photo

Figure 19: Concept imagery of SSUD

Source: Software generated photo

5. Theses urban districts will be planned for a finite population including 30% more for future adaptation as well for finite private cars and vehicles. But due to some socioeconomic and behavioral factors, people might want to live away from the work district and for them the following fictional green city is the answer.

Fictional green city model:

Obviously the core units of this fictional green city are SSUDs and arranging many SSUDs in various patterns SSUD City will be developed. The city would have the following characteristics but not limited to:

1. SSUDs would have their commercial establishments on one or two sides of the district if assumed rectangular. The other sides of the SSUDs would join the same sides of other SSUDs. Thus a greater carbon free pedestrian green areas will be ensured.

2. The outer secondary roads of combined SSUDs will be predominantly designed for rapid transit like Curitiba, Brazil.

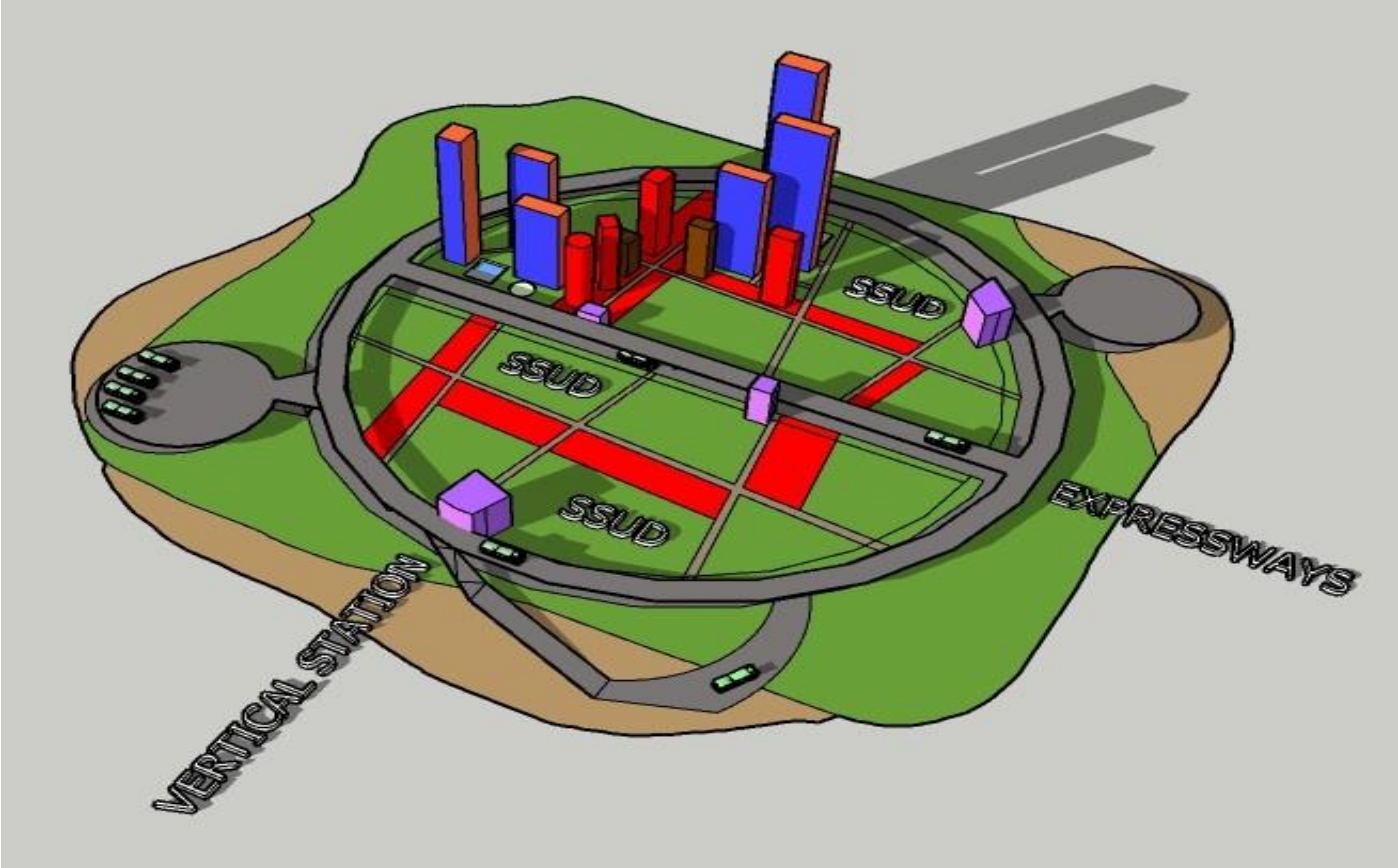
3. There would be high speed and less interrupted primary expressway roads would have no commercial or any kind of establishments on either sides while buffered from the SSUDs by the green or water bodies.

Figure 20: Conceptual imagery of SSUD City

Source: Software generated photo

4. The primary roads might have tiers and would not be lowered down in places of the city except the both ends of city periphery while will be connected with high speed ring roads. Vertical stations will be used to reach the tiers.

Figure 21: Conceptual model of SSUD City.



Source: Software generated 3d model

5. Utility lines and goods tunnels with conveyor belt system will run at the sides or center of every tier as well drone delivery will reduce traffic.
6. Intelligent smart real time traffic management systems, waste management systems, smart land use and population management systems, sustainable solar energy and greenhouse development on roofs and many other innovative approaches along with the vertical development and control on urban sprawls will be adopted to get a livable SSUD City.

Implementing the models on existing neighborhoods and the city:

It is a challenge to apply this SSUD model and SSUD city on existing neighborhoods and city. Still here are some guidelines to implement these models on existing environment of 3 cities we studied earlier:

1. It is seen that, all these three cities have random mix use developments in study areas. To implement SSUD model all the commercial and mix use establishments in every small neighborhood need to be encouraged to house their owners and employees in the same neighborhood.

2. Commercial establishments in rich neighborhoods will be asked to relocate their low income employees in adjacent neighborhoods of lower land values as well high income employees in their own area. To save trillion wastage GDP from congestion, states should take subsidized urban policies to implement SSUD.

3. Big block vertical developments will help to save lands in the neighborhood with the consent of the community. Vertical parking projects besides the neighborhoods need to be initiated throughout the city to keep the residential areas of the districts free of cars and carbon. Strict land use control, vehicles and population and occupancy control in every neighborhood need to be ensured.

4. Along with these mesoscopic initiatives, macroscopic changes need to be done for the entire city following the SSUD City model. Less interrupted multi level high speed expressway like SSUD City should be implemented. Emphasis on public transport and clean energy vehicles need to be promoted.

Limitations and Further Research:

SSUD is mainly relied on vertical development but our socio economic condition or behavior might not always support vertical developments. To satisfy this issue, SSUDs will be developed according to the demands while all other policies of SSUD need to be ensured. Again when SSUD need larger area that could not be covered by 10 minutes walking, spatial design of SSUD is required.

Implementing these SSUD models on existing cities will be a very complex job specially in democratic states. Relocation of commercial entities and amenities along with related people will face a great challenge due to the private ownership of establishments or buildings in democratic economy. While it will be much easier in socialist states because the ownership of the establishments and the buildings is under control of the socialist governments. Further it is a well established phenomenon that, private cars and vehicles in a city increase congestion while public transport helps to make a livable city. Thus future research is needed about the impact of private ownership of real estate on traffic congestion in a city.

Only residential areas of SSUDs are suggested to be carbon free but how the whole city could be an exhaust free zone by implementing public and clean energy transport while challenging the private transport business in less developed countries, could be an area of further research.

3. Conclusion

“Home and workplace, within walking distance to each other”, following this concept, Self-supportive urban districts could lessen the peak hour traffics much lower. Further its car or vehicle free residential areas will enhance the quality of life of the residents as well public amenities like parks, public swimming pool, gymnasium, play fields, water bodies etc. within walking distance and absence of boundary walls in residential areas will enhance the communication in community.

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