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Sustainable Mobility in a Tier Two Indian City: A Focus on Gwalior City

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Abstract: ***Cities are the focal point of Coronavirus outbreak. People in cities are experiencing the reality of less travel and a shift in activity to the internet. This is a great chance to reassess our work, leisure and retail habits, as well as to debate the necessity of fostering affordable and sustainable travel for everybody. Lower greenhouse gas emissions, which contribute to a cleaner climate, will result in significant public health advantages as a result of action toward sustainable mobility. This paper is an attempt to identify strategies that will aid in the development of an efficient, environmentally viable transportation system that can function within the existing fabric of the city of Gwalior.***
Keywords: Pandemic, sustainable mobility, non-motorized transportation

I. INTRODUCTION

The global spread of the COVID-19 pandemic has had a significant influence on a number of countries. Policies that promote sustainable mobility and better land-use planning will successfully boost the usage of walking, cycling, and public transportation while also reducing neighborhood divides and wasteful journeys. During the Covid-19 outbreak, the World Health Organization (WHO) has provided professional advice on how to move around. To prevent the pandemic from spreading, the suggestion recommends riding and walking to avoid physical contact. “Whenever possible, consider riding bicycles or walking; this provides physical distance while also assisting in meeting the minimum requirement for daily physical activity, which may be more difficult to meet due to increased teleworking and limited access to sport and other recreational activities” [1].

A. Severity of Pandemic in India

On 30 January 2020, the first case of COVID-19 in India was registered. As of 8 May 2021, India had the world's second-highest number of confirmed cases (after the United States), with nearly 20 million reported cases of COVID-19 infection and 242,362 deaths [2]. India began its vaccination programme on 16 January 2021, as of 1 May 2021, less than 2 percent of the population has been vaccinated[3]. The second wave of this Pandemic is rapidly approaching a catastrophic epidemic in India, with hospitals becoming unbearably overcrowded, oxygen stocks running low, desperate people dying in line waiting to see doctors — and mounting evidence that the real death toll is much higher than officially announced [4]. "The speed of spread in the second wave is twice as fast as in the first wave.” “Partly due to variants and partly lowering of the guard,” clarified virologist T Jacob John, a professor at Tamil Nadu's Christian Medical College (CMC) [4].

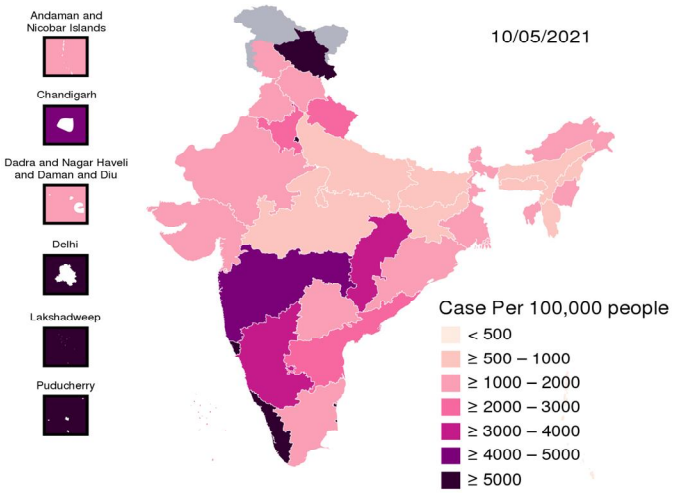

Fig. 1 Map of cumulative COVID-19 cases in India by states and UT. (Source: MoHFW)

The goal of a post-pandemic city should be to build a healthier, more prosperous, and resilient community, not to return to "normal." Urban planning should lead the way in establishing ways to aid in community regeneration and lay the groundwork for efficient post-pandemic cities. We've all been thrown in a live laboratory full of examples of what a more sustainable future might look like as a result of the lockdown. City planners have a unique opportunity to learn about and study which of these routes can lead to a more sustainable and healthier urban environment.

Urban mobility is one of the most immediate and significant repercussions of the present pandemic in cities. The relationship between mobility, urban settings, and health, in particular, needs to be rethought in order to improve urban environments through new sustainable transportation models.

B. Need For Sustainable Urban Mobility

Cities, in particular, as dense centres of mobile people, increased land uses, transit networks, and social connections, are more vulnerable to contagions than rural areas. Intercity and intracity transportation systems, airports, ports, hubs, CBDs, and other densely populated places all pose additional hazards to cities and make them more prone to pandemics. Social distancing and wearing of mask are the most popularized precautionary measures to limit the spread of COVID-19. By following social distancing, public transportation networks are unable to operate at full capacity. The Public transportation in cities has been losing its competitiveness which in turn brought the dependency of citizens upon private vehicles. If people use car instead of taking public transportation, cities risk losing some of the most important social and economic advantages of public transportation and being plagued by traffic and air pollution.The COVID issue has increased the possibility of a reduction in the long-term viability of urban transportation, which could impede policymakers from achieving their long-term development goals. These consequences should cause us to ponder how urban mobility will alter in the aftermath of the crisis.

Today, the cities are in need of a solution which will lead them towards Sustainable Urban Mobility, so that the urban environments will remain healthy and livable. This Pandemic can be an opportunity for the planners to develop and enforce a system of urban mobility which is environment friendly, cost effective, sustainable and further leads towards resilient cities.

C. Initiatives Taken by Various Cities Worldwide for Sustainable Mobility During Pandemic

Several cities around the world have already announced or implemented measures aimed at enhancing sustainable mobility, particularly measures designed to enable people to move safely in urban spaces, while also acknowledging that physical separation will be the standard for the foreseeable future, in order to support a low-carbon, sustainable path out of lockdowns. In order to respond promptly to these new needs and facilitate the reopening of enterprises, many local governments are developing and altering urban spaces to cope with this new urban state. The bulk of measures in the region strive to increase non-motorized mobility as well as the availability of public places and facilities. Several global cities, in particular, have opened their streets to walkers and bikes, capitalising on the COVID public health crisis to initiate the necessary urban transformation for the green vision of the future. The prolonged crisis has sparked a new urban movement centred on environmentally friendly values.d facilities around the region.

1) *Paris:* Paris has already announced plans for a comprehensive transformation of the city by 2024. Plan Vélo (Paris City Hall, 2019) is a plan based on the concept of “ville du quart d'heure,” or a city where all a citizen needs is within a 15-minute non-motorized walk [5]. The plan offers any required amenity in terms of recreation, shopping, schools, and public services to all neighbourhoods, all within walking or cycling distance[5]. It was launched in 2019 and has already resulted in a more than 50% rise in bicycle usage. To provide an alternative to public transportation, the local government has already allocated $300 million for a network of permanent and pop-up bike lanes in the Ile de France Region, many of which will follow existing metro lines [5]. By the end of lockdown, the pop-up cycling network will be complete.
2) *London:* The Mayor's Office and Transport for London jointly unveiled the London Streetscape Plan [6], a massive redesign of public roads aimed at creating new walking and cycling paths along major highways, including temporary bike lanes. The project will tenfold the amount of bicycle and pedestrian space available, making it easier for individuals to walk and bike to work. Physical separation, which is nearly impossible on crowded public transportation, will force millions of daily journeys to be undertaken by other means[6]. With London's public transportation capacity down to one-fifth of pre-crisis levels, the number of people who use public transit must be kept to a minimum [6]. Sadiq Khan, the mayor, revealed that the city has already started working with boroughs to establish a strategic bicycle network using temporary materials, calling COVID-19 "the greatest threat to London's public transport network in Transport for London's history" [6]. The new route network would eliminate crowding on public transportation and fully transform local town centres, allowing people to stroll and bike wherever possible in low-traffic areas [6].

3) *Mexico:* The Mexican government announced the development of new bike paths to keep people off public transportation in Mexico City, one of the world's most populous cities. The most recent "Ciclovia temporal CDMX" consists of 80 miles of temporary bike lanes and is part of the administration's long-running Plan de Movilidad no Motorizada [7] effort. The proposed bike lanes are designed to provide a feasible choice for sustainable urban mobility in terms of social distancing by following the main lines of public transportation.

4) *New York:* New York declared intentions to open 100 miles of streets to "socially responsible recreation" during the COVID-19 crisis [8]. Two of the city's busiest bike corridors will get temporary safe bike lanes, according to Mayor de Blasio [8]. These emergency lanes offer a chance to reclaim the empty roadways and establish areas where walking and cycling are the preferred modes of transportation. Up to 60 miles of open streets will be parallel to parks, up to 20 miles will be the product of neighbourhood consultations, and the remainder will be permanent protected bike lanes [8].

II. STUDY AREA

Gwalior, India's Tier II city, has a population of 1069276 people [9]. The city has a rich cultural heritage and is historically significant. Located on the periphery of Madhya Pradesh, Gwalior is situated 321 kilometres from Delhi and 121 kilometres from Agra [9]. The city's population is currently projected to be 1410000 people.

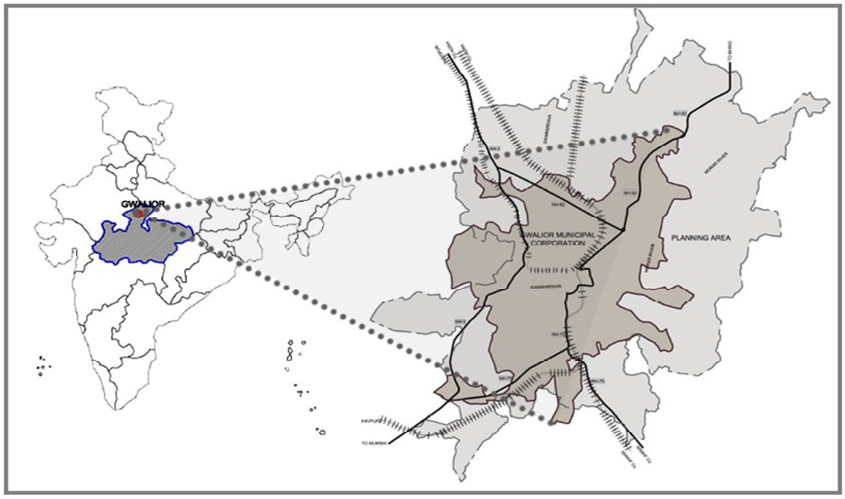

Fig. 2 Location of Study Area (Gwalior) (Source: GMC)

Gwalior is experiencing rising pollution, road congestion, and safety concerns for pedestrians and cyclists as a result of substantial urbanisation and a rapid expansion of motorised traffic.

TABLE I
Gwalior Municipal Corporate Highlights

Gwalior Municipal Corperation Highlights	
Location	26.22N 78.18E
Average Elevation	197 Meters i.e. 646 Feets
Municipal Corporation Area (Census 2011)	173.68 Sq. Km.
Municipality Area (Development Plan 2021)	18985 Hectares
Planning Area(Development Plan)	42652 Hectares
Planning Area and Special Area(Development Plan)	73279 Hectares
Total Wards	66
Sanitary Zones	25
Number of Households	202066
Total Population(2011)	1069276
Present Population(2018)	1400000 approx.

(Source: Gwalior Development Plan)

III. TRAFFIC AND TRANSPORT PROFILE OF GWALIOR CITY

In Gwalior, the urban transportation scene is chaotic, with varied traffic seeking for road space. Due to the lack of a public transportation system, the majority of the city's population relies on private vehicles. In addition to personal information, Intermediate Public Transportation (IPT) meets the demand for mobility. Tempos, auto rickshaws, TATA magic, taxis, e-rickshaws and other forms of IPT are available in the city.

A. Road Network

National Highways, State Highways, Arterial Roads, Sub arterial Roads, and Collector Roads make up Gwalior's road hierarchy. The city's road network includes a mix of radial and grid roads with a total length of 782 kilometres [10]. The Public Works Department (PWD) is responsible for state roadways, whereas the National Highways Authority of India (NHAI) is responsible for national highways.

TABLE II
Existing Road Details

Type of Road	Length in Kms
National Highway	68
State Highway	15
Arterial / Sub artrial	105

(Source: City Development Plan 2011, Gwalior)

There are ten arterial roads, sixteen sub-arterial roads, thirty collector roads, and eighteen smaller roads that connect the city's residential and commercial districts [10].

B. Vehicular Growth

Over the years the city has experienced a rapid growth in private vehicles (2 wheelers and 4 wheelers). The Table presents the growth of the vehicle.

TABLE III
Registered Vehicle Trend in Gwalior

Years	Two Wheelers	Three Wheelers	Four Wheelers	LCV	HCV	Mini buses	Buses	MAV	Total
2003-04	15990	299	2284	51	610	390	9	2	19635
2004-05	18142	338	2670	132	457	331	47	0	22117
2005-06	18623	387	2183	107	403	294	73	80	22150
2006-07	19446	520	2320	178	775	252	40	768	24299
2007-08	18774	842	2546	144	201	367	88	302	23264
2012-13	18825	844	2553	144	202	368	88	303	23328

(Source: City Development Plan 2011, Gwalior)

C. Modal Split

The modal spilt in figure 3 shows that NMT trips account for 59 percent of all trips. Despite the enormous number of automobiles, it is clear that only 22% of demand is met by private vehicles. This emphasises the importance of improving NMT infrastructure to retain a large number of NMT users [11].

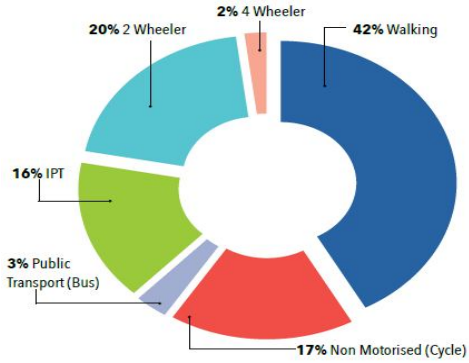

Fig. 3 Modal split in Gwalior (Source: City Development Plan 2011, Gwalior)

D. Public Transport (PT)

Gwalior does not have a formal public transportation system. In the absence of city bus service, IPT meets the city's shared mobility needs.

E. Intermediate Public Transport (IPT)

In the absence of formal public transportation, IPT is critical in meeting mobility demands. Auto rickshaws and shared vehicles such as Tempos and Tata Magic, which ply in the city and nearby villages, are the key modes of IPT in Gwalior. In Gwalior, the most popular IPT vehicle is currently Vikram service commonly named as Tempos. According to RTO info, the city has 826 registered tempos. Out of the 23 routes allocated by the RTO, 14 are operational. Low demand has resulted in little interest from Auto drivers on the remaining 9 routes. Aside from the tempos, there are over 8000 autorickshaws and 450 Tata Magics in the district [11].

Fig. 4 IPT in Gwalior City (Source: Shakti Sustainable Energy Foundation)

F. Pedestrian and Non-Motorized Transport (NMT Infrastructure)

Walking, cycling, and horse-drawn Tongas are the most popular non-motorized modes of transportation in Gwalior. Tongas are primarily used for passenger transport in the Bada area. In Gwalior, about 20% of trips are made by cycle whereas Tongas contributed only 0.38 percent. Furthermore, approximately 45 percent of commuters choose to walk to work, school, and other activities. However, services for pedestrians such as the provision of footpaths and other amenities is insufficient throughout the city.

1) *Public Bike Sharing:* Under Gwalior Smart City Mission, Public Bike Sharing has been officially started on 4 September 2019. It plans for 50 PBS Stations comprising of 500 bicycles which stretch over a length of 42 kms. The PBS in Gwalior is run by Yaana Smart Technologies Private Limited. The Gwaliorites enthusiastically accepted the change. According to the Gwalior Smart City Corporation, Gwalior has peddled more than 2,50,000 kilometres as of December 28, 2020.

Fig. 5 Public Bike Sharing routes (Source: Shakti Sustainable Energy Foundation)

Fig. 6 Public Bike Sharing stand (Source: Shakti Sustainable Energy Foundation)

2) *E-Rickshaw:* The use of E- Rickshaw and E- Loaders are very limited in Gwalior. This is because of the lack of appropriate infrastructure required for its functioning i.e. Charging Stations, Parking Spaces and Proper Training of Drivers. The Gwalior Smart City Development Corporation Limited has signed an agreement with Entice Impex Pvt Ltd (an E-rickshaw vendor) for the supply of E-rickshaws and E-loaders, as well as the construction of charging stations, service stations, and comprehensive warranty and maintenance.

G. Parking Facilities

Because of the large number of private cars on-street parking, which is currently unorganised and producing congestion and traffic jams along the city's main road sections, has taken over the streets. While parking facilities are available in the area, they are insufficient to meet current demand. In Gwalior, there are 20 reserved on-street parking spaces. 14 of these are run privately by tenders, while the remaining six are operated by GMC. In addition, the city has 11 operational off-street parking lots. Six of them are in the Maharaja Bada district, which has been designated for Area Based Development under the Smart Cities mission [11].

IV. PERCEPTION STUDY FOR NON-MOTORIZED TRANSPORTATION

A. Bicycle Survey

A perception analysis is conducted by distributing a 15-question questionnaire to cycling clubs in the city, students in schools and colleges, bureaucrats from Gwalior smart city and Nagar Nigam, people employed on daily wages, and some commercial areas. The target audience includes people of various ages. A total of 85 responses are collected.

Based on the results of questionnaires, it was discovered that 80 percent of people prefer cycling to promote sustainable mobility, with the majority of them being between the ages of 10 and 30. Presently, students and people from the working class mostly use bicycles. 65 percent of people have adopted public bike sharing, and the majority of them use it for short distances of 5-10 kilometers. 40% Peoples are willing to shift their current mode of travel to bicycle.

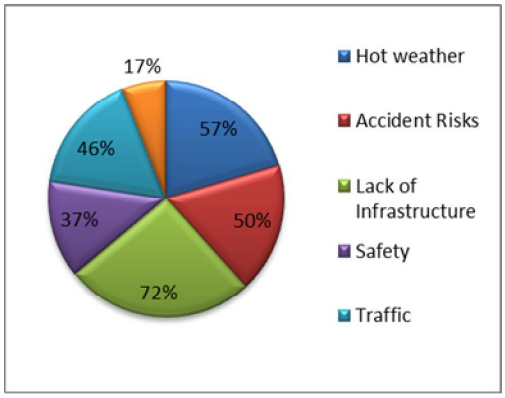

Fig. 7 Various problems identified while using Bicycle (Source: Survey Questionnaire analysis by Author)

Various Benefits and drawbacks of using Public Bike Sharing identified on discussion with peoples are:

1) *Benefits*

a) Get rid of hassles like Vehicle theft, police challans and buying bicycles for children.

b) 24 Hours availability

c) Cheap mode of travelling

d) Improved Health
e) Helps in decreasing pollution
f) Environment Friendly
g) Freedom from wear and tear, maintenance and puncture etc.

2) Drawbacks
a) You will not get a card or membership without smartphone. As a result the students and various citizens belonging from low income groups (who mainly uses this facility) deprived of using this.
b) Cycle stations are built at some places in Lashkar, Murar, City Centre and Hazira. While a large part of the city is untouched by the public bike share facility where this facility is currently unavailable.
c) The meter will remain on till the cycle reaches the station.

B. Survey For E-Rickshaw

A perception study is conducted, in which road users in Gwalior City are asked a questionnaire with seven questions, and people of all ages are considered. A total of 50 samples were taken. Age group, gender, job profile, main mode of transportation, and willingness to switch from current mode to e-rickshaw are all factors to consider. The survey's main concerns include: comfort, cost effectiveness, safety, on-time availability, and connectivity.

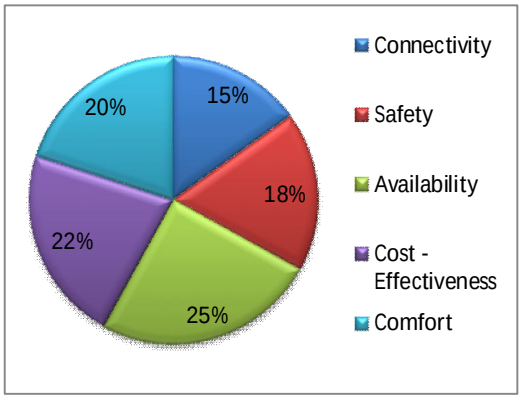

Fig. 8 Various problems identified while using E-Rickshaw (Source: Survey Questionnaire analysis by Author)

25% peoples are willing to shift from current mode of travel to E- Rickshaw for 2-5 km daily trip. Majority of them belongs to the age group of 21-40 years. Majority of respondents (25%) agrees that e- rickshaw is available in their locality but 15% feels connectivity issues. Due to Covid -19 emergency only 20% respondent feel comfortable in using public vehicle i.e., E- rickshaw.

V. ANALYSIS AND INFERENCES

The city's population grew at a rapid pace in the previous two decades (see chart-1), resulting in the emergence of a slew of new residential neighbourhoods on the outskirts.

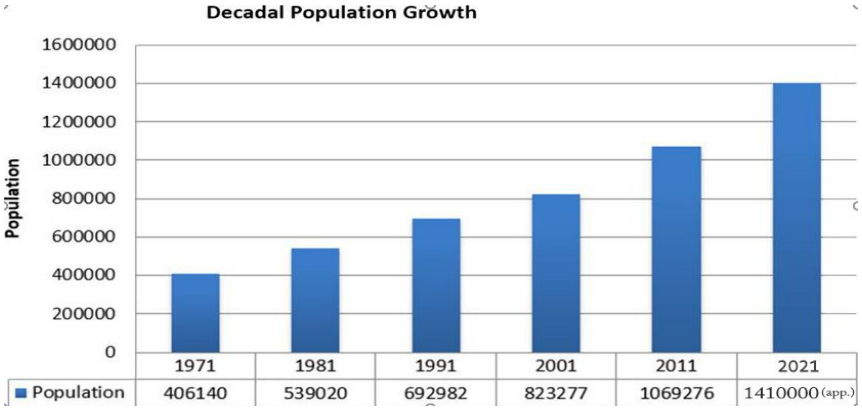

Fig. 9 Decadal Population Growth Chart (Source: Gwalior Development Plan and Census)

According to the Gwalior Development Plan, residential land accounts for 2803 hectares, or 6.6 percent of the total planning area. Transportation takes up 997 hectares of land, or 2.3 percent of the total planning area [10]. Directly proportional to population growth, the issue of traffic management has become one of the city government's top priorities. The non-motorized form of transportation i.e. Cycling is the most effective post pandemic means of transportation as it does not pollute environment and ensures social distancing. At present, the city is following the transportation pattern with maximum peoples using motorized vehicle such as private cars and two wheelers and minimum users for non-motorized vehicles and pedestrians.

Various factors lead towards discouragement of cycling in Gwalior City are:

1) Car-oriented city planning and poor cycling infrastructure.
2) Cycling is considered Unsafe and have the highest share of traffic accidents.
3) It is considered a 'poor man's' mode of transport.
4) The Climatic conditions restricts the use of cycling with a mean temperature range 37 ºC, highest temperature 44 ºC which is not comfortable for cyclist.
5) Females are reluctant to use bicycles due to long trip length, risk of road accidents and cultural dilemmas.

To ensure the city's long-term viability and health we have to promote pedestrianisation. This will reduce noise and pollution in the city while also improving quality of life of the citizens. Various efforts are needed in the city in order to promote non-motorized modes of mobility. Here are some ideas that have been taken by front-line cities and have shown to be effective [12-15]. Also, these suggestions are practicable in the existing fabric of the city:

A. Attractive Streetscape with Expansion of Pedestrian Areas

To make walking a safe and enjoyable means of transportation and exercise, motorised vehicles should be removed from residential areas and walkways should be extended near stores, schools, and parks. A pleasing streetscape and public realm with design elements that are coordinated to provide shade, weather protection, pedestrian amenities, and visual appeal improves the desire to walk and decreases the perception of distance.

B. Proper Cycling Infrastructure

Creating safe cycling routes to and from schools, offices, and major thoroughfares, as well as closing roads and carriageways if needed, to provide a safer alternative to private cars and public transportation. New bike lanes can be established beside important urban thoroughfares by repurposing existing automobile lanes. The maximum speed on the lanes will be 20 km/h to give cyclists and pedestrians preference. Furthermore, the recently created formula of temporary or pop-up bike lanes reduces implementation timetables and costs significantly, allowing local governments to define huge networks throughout the city in a short amount of time and on a low budget.

C. Traffic Calming Areas with Proper Green and Open Spaces

At the neighbourhood level, traffic calming areas include the establishment of safe pedestrian and bicycle routes, as well as safe common areas and greenways, as well as the closing of roads and squares to motor vehicles.

D. Incentives for Supporting Sustainable Mobility

The municipal or state government could propose financial incentives for residents to buy bicycles, e-bikes, and micro mobility, as well as new legislation to encourage and facilitate the establishment of cycling lanes on city streets. The city mobility plan can provide services such as sharing mobility (e-bikes and scooters), as well as pedestrian and traffic calming areas within the city, to reduce car traffic and increase pedestrianisation.

E. Promotion of Decentralisation of Services and Goods

For the city's long-term sustainability and environmental protection, we must rebuild our city regions or neighbourhoods and promote decentralisation of services and commodities, so that everything we need is within a 15-minute non-motorized walk. New legislation should be enacted to rezone streets such that vehicles are removed and pedestrians and bikes are given priority. All neighbourhoods should have access to various essential amenities such as recreation, commerce, schools, and public services, all of which should be within walking or bike distance. A 15-minute city seeks to supply everything you need in 15 minutes or less, including jobs, schools, restaurants, parks, community, medical, and more. This urban design concept, based on the concepts of New Urbanism and popularised by Parisian Mayor Anne Hidalgo, could be a way to make cities more sustainable, equitable, and healthy.

F. Improvement of Digital Services and IT Infrastructures

These policies can have beneficial consequences, for example, the digitization of municipal services might minimize the need for travel while also limiting physical interactions between city officials and citizens. Furthermore, information technology can enable a quick and direct response to the public requirements.

VI. CONCLUSION

Many cities around the world are developing pedestrian and bicycle facilities, as well as economical mass transit, to take advantage of the opportunities presented by the pandemic, particularly low car numbers. The major goal is to reduce traffic significantly, freeing up more road space for cycling and walking.

Indian cities have a long history of mixed land use, with the highest proportion of commercial and residential usage. In our cities, the residents have a habit of using the ground floor for commercial purposes and the upper floors for residential purposes. The Indian cities have progressed on the correct track since mixed-use development fits the aim of reducing motor-trips. However, the ever-expanding Indian cities require micro-mobility measures, despite having a history of walkability-oriented and accessibility-enhanced city development. Area-based planning strategies could be crucial in helping these cities achieve the requisite resilience.

The current crisis has provided the impetus for a significant transformation in urban planning. In particular, urban mobility is witnessing a new kind of green revolution. Our vision of our streets and public spaces as valuable assets that can be used to alter urban transportation has shifted dramatically.

The inferences contained in this study can be easily implemented in many urban environments, both temporarily and permanently. As a result of this research, policymakers and planners may be able to establish green policies, develop models, strategies, and activities that are appropriate for the current city environment.

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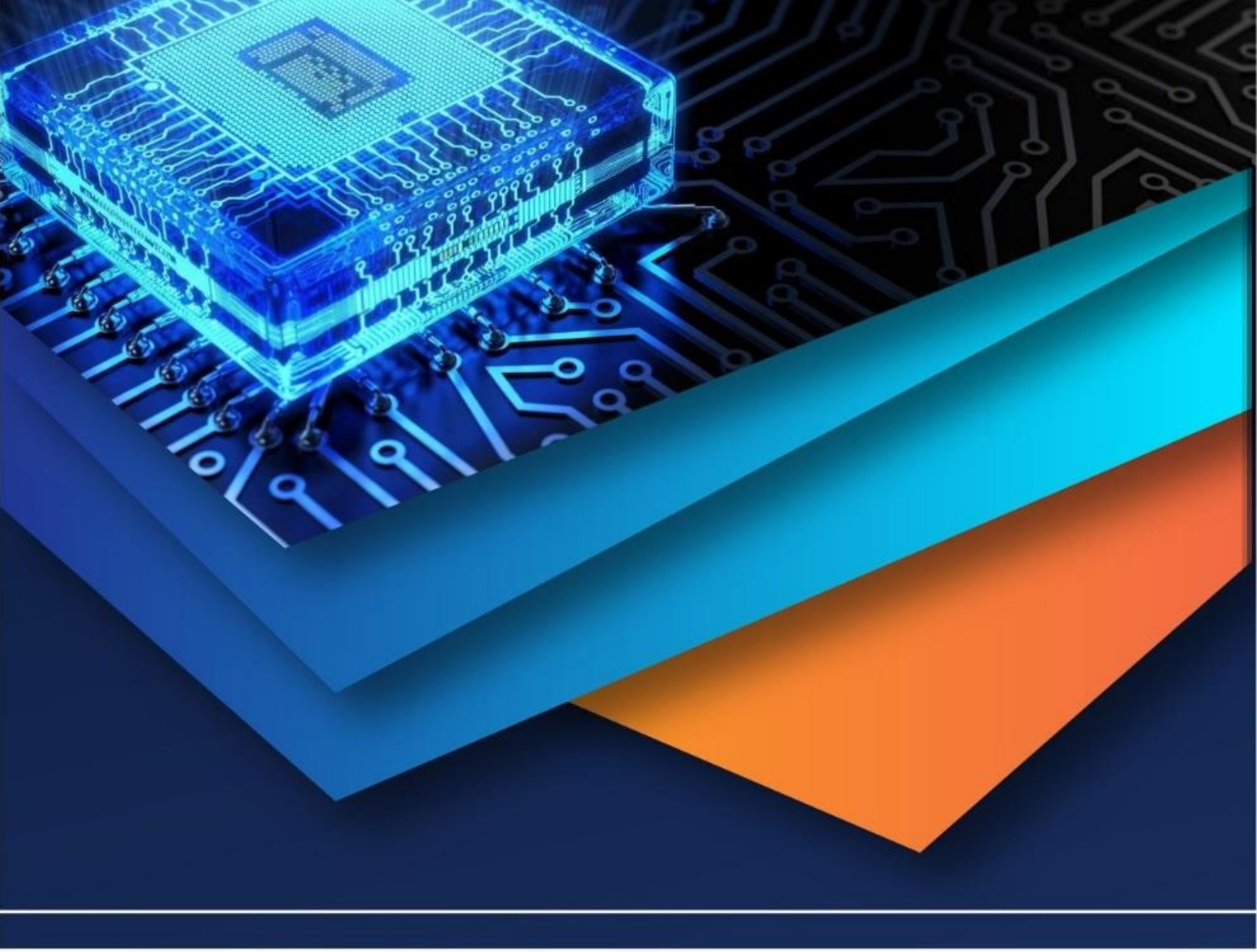

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