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Sustainable Urban Mobility in Emerging Indian Cities: A Comprehensive Study of Green Transportation Integration in Rewa's Urban Planning Framework

Karnika Dwivedi[1], Dr. D.K Jain[2]
[1]*M.Tech Scholar, Civil Engineering Department Rewa Engineering College, Rewa MP, 486001*
[2]*Professor, Civil Engineering Department Rewa Engineering College, Rewa MP, 486001*

Abstract - Rapid urbanization in major cities across the world necessitates hasty advancements in the transportation industry to satisfy the demands of both people and products in terms of mobility. This leads to the need for excessive transportation activities, which in turn causes traffic jams, mobility issues, unequal access, poor road safety, excessive greenhouse gas emissions, and, most importantly, an unsustainable environmental state with a carbon footprint that is larger than the cities' biological capacity to absorb this enormous amount of carbon. Consequently, green transport, also known as environmentally sustainable transport, is becoming a more significant research factor for transportation planning and policymaking. It can meet travel demand, improve air quality, and lessen the transportation sector's contribution to climate change. Particularly in the megacity of Rewa, where transportation greatly exacerbates environmental degradation by emitting enormous volumes of carbon dioxide and other air pollutants, green mobility has become a feasible alternative for sustainable transportation. The city is also in disorder as a result of inadequate public transportation, an increase in the use of private vehicles, and conditions that discourage walkers and others who do not utilize motorized transportation. In addition to developing an index for a quantitative evaluation of transportation sustainability that takes environmental factors into consideration, this study aims to offer some strategic possibilities for the development of environmentally friendly transportation. The main objective of the study is to develop a "Green Transport Index (GTI)" at the mesoscopic level in a few regions based on vehicle emissions, walkability, and public and non-motorized transportation options.

Key Words: Green Transport Index, sustainable transport, environmental degradation, quantitative evaluation.

1.INTRODUCTION

Transportation, sometimes called the "maker and breaker of cities," is thought to be a crucial element of future city livability. Societies depend on efficient transportation, yet it must be improved without unacceptable detrimental repercussions. A well-planned and constructed transportation infrastructure influences a city's growth trajectory and level of economic activity in addition to providing citizens with more mobility options. The system is therefore essential since the transportation sector is responsible for 10% of the world's GDP, 22% of its energy consumption, 25% of its fossil fuel burning, and 30% of its greenhouse gas emissions and air pollution.

The state as a whole is exacerbated by inadequate public transportation, inadequate pedestrian facilities that offer little protection from crashes, poor road space management, and lax enforcement of traffic regulations, in addition to traffic bottlenecks, emissions, and air pollution. In this sense, the macro-level "Green Transport" (GT) plan for Rewa city marks a new frontier in the pursuit of an efficient transportation network. Green transportation is just a continuation of sustainable transportation from an environmental point of view. It aims to achieve sustainability in the transportation sector by reducing traffic emissions, promoting walking and public transportation, utilizing well-designed signal systems, promoting fuel-free transportation, and introducing a range of policy options for ensuring traffic safety as well as win-win strategic solutions for efficient movement.

2. LITERATURE REVIEW

Schofer (2013) Using group travel technology like buses and trains, public transportation makes sure that people can move throughout cities. Carrying a large number of passengers in a single vehicle (such as busses) or a group of connected vehicles (such as trains) is the fundamental characteristic of mass transit. This enables more efficient movement of people in the same travel corridor, which may result in lower transportation costs per person, the chance to spend more on superior service because the expenses are shared by many, or both.

Kamal-Chaoui L. and associates (2011), The plan asks for specific actions targeted at cities, such as the development of ecocities, green building projects, and green infrastructure. To help local authorities implement the Strategy, a number of policy papers were developed, including the Action Plan for Greening Transportation. The primary goals of the action plan are to implement the compact city plan following transit-oriented development, prioritize investments in low-carbon transportation infrastructure, and create a "Green Traffic Priority Region" to manage areas with high traffic. Additionally, it enhances the infrastructure for pedestrians and bicycles by establishing pedestrian priority districts. Additionally, BRT encourages the use of public transportation.

Gota and colleagues (2010) Among numerous walkability indices available throughout Asia, the Ministry of Urban Development (MOUD) of India uses one that is based on the assessment of pedestrian amenities and the presence of walkways. In a similar vein, the popular website "walkscore.com" measures the distance between residences and nearby amenities to assess how walkable a community is. For the World Bank, H. Krambeck developed the simple method known as "Global Walkability" that provides a qualitative evaluation of the walking conditions, including the pedestrian environment's convenience, safety, and security.

3. OBJECTIVES

1. The purpose of this study was to explore the proper strategies for emission reduction, promoting walking, public transport and Fuel free transport to have a sustainable transport solution from environmental viewpoint.
2. To determine suitable transport strategies to reduce the problems identified from the green transport index values in different study areas.
3. To develop green transportation index based on; vehicular emission, walkability, facilities of public and non-motorized transport, at mesoscopic level in selected areas.

4. METHODOLOGY

- Topic Selection.
- Fixation of objectives
- Literature review
- Selection of study area
- Field Work & Reconnaissance survey
- Traffic Volume survey
- Public transit average speed survey
- Bus service average waiting time survey & Bus service level of comfort survey
- Non-motorized transport access time survey
- Data Analysis, Output & Interpretation
- Suitable transportation strategies for improving green transport index value
- Conclusion & Recommendation

5. SELECTION OF STUDY AREA

With latitude 24.5362° N and longitude 81.3037° E, Rewa is a city in the northeastern region of the Indian state of Madhya Pradesh. Rewa district is a maximum of 125 km long from east to west and 96 km long from north to south. The Vindhyachal mountains cut across the center of the district, and the Kaimur hills encircle this region to the south.

Fig 2. Selected Area for Study

6. EMISSION AND BIO-CAPACITY SCORE ESTIMATION

1. **Total CO2 emission in different areas**

Table 1. Total CO2 emission in different areas

Area	Ton CO2/Day	Ton CO2/Year
Neem Tiraha	0.602	219.73
Janta College	0.795	290.175
Stadium Intersection	0.975	355.875
College Square	1.1699	427.014

2. Bio-Capacity Estimation Process

Area	Land Use	Area (Hectare) (A)		Yield Factor (YF)		Equivalency Factor (EQF) (gha/hectare)		Biocapacity (gha)
Stadium Intersection	Built-Up Land	52.80	X	1.85	X	2.51	=	245.18
	Forest land	20.58	X	1.00	X	0.37	=	7.62
	Fishing	0	X	0.35		1.26	=	0
	Total Bio-capacity							252.8

Table 4. Bio-capacity estimation College Chowk intersection

Area	Land Use	Area (Hectare) (A)		Yield Factor (YF)		Equivalency Factor (EQF) (gha/hectare)		Biocapacity (gha)
College Chowk	Built-Up Land	65.21	X	1.85	X	2.51	=	302.80
	Forest land	12.12	X	1.00	X	0.37	=	4.48

	Fishing Ground	0.21	X	0.35		1.26	=	0.093
	Total Bio-capacity							307.37

Table 5. Bio-capacity estimation Janta college Square

Area	Land Use	Area (Hectare) (A)		Yield Factor (YF)		Equivalency Factor (EQF) (gha/hectare)		Biocapacity (gha)
Janta College	Built-Up Land	58.64	X	1.85	X	2.51	=	272.29
	Forest land	18.39	X	1.00	X	0.37	=	6.80
	Fishing Ground	0.59	X	0.35		1.26	=	0.26
	Total Bio-capacity							279.35

Table 6. Bio-capacity estimation Neem Tiraha

Area	Land Use	Area (Hectare) (A)		Yield Factor (YF)		Equivalency Factor (EQF) (gha/hectare)		Biocapacity (gha)
Neem Tiraha	Built-Up Land	44.41	X	1.85	X	2.51	=	206.22
	Forest land	22.57	X	1.00	X	0.37	=	8.35
	Fishing Ground	0.52	X	0.35		1.26	=	0.23
	Total Bio-capacity							214.8

Dividing the bio-capacity area by carbon uptake land BCR ratio is determined. This BCR ratio is used for "Emission and bio-capacity score" estimation.

Table 7. Emission and bio-capacity score of different study area

Area	Carbon Uptake Land (gha)	Bio-capacity Area (gha)	BCR	Score value	Descriptor
Neem Tiraha	61.57385	214.8	0.287	4	Worst
Janta College	81.3143	279.35	0.29	4	Worst
Stadium Intersection	99.725009	252.8	0.39	3	Bad
College Square	119.66	307.37	0.39	3	Bad

BCR ratio for below 0.33 for two out of four study areas; this implies that the bio-capacity is in critical condition; carbon uptake is extremely high compared to biologically productivity.

7 GLOBAL WALKABILITY SCORE ESTIMATION

The quality and connectivity of sidewalks, walkways, and footpaths in urban areas are referred to as "walkability"; it also describes how enjoyable a place is to walk.

Table 8. Combined Global Walkability Score (GWS) for selected areas

Area	Weighted Walkability Score	Score Value	Descriptor
Neem Tiraha	52.15	2	Waiting to walk
Janta College	56.95	2	Waiting to walk
Stadium Intersection	57.92	2	Waiting to walk
College Square	48.79	3	Walking difficulties

8 Public Transit Facitlity Score Estimation

Table 9. Public Transit Facility Score (PTFS) for selected areas

Area	Service coverage Score	Average Waiting time Score	Service quality Score	Speed Score	Calculated score	Overall Score	Descriptor
Neem Tiraha	1.0	3.0	2.0	3.0	9	3	Bad
Janta College	1.0	3.0	2.0	4.0	10	3	Bad
Stadium Intersection	1.0	3.0	2.0	4.0	10	3	Bad
College Square	1.0	3.0	2.0	4.0	10	3	Bad

9 NON-MOTORIZED TRANSPORTATION (NMT) FACITLITY SCORE ESTIMATION

The infrastructure for non-motorized transportation (NMT) is one of the most important markers of efficient modes of transportation that are favored and approved by sizable market segments. These facilities are also beneficial in terms of cost-effectiveness and environmental purity. Non-motorized transportation facilities vary in size and shape according to their contextual appropriateness and significance within broader transportation systems. In order to estimate NMT facility scores for certain Rewa city regions in a manner that is compatible with all of the selected study locations, this study considers NMT facilities linked with urban areas.

9.1 Non-motorized Transportation facilities score in different areas

All three features are expressed as the total score for non-motorized transportation facilities in different areas in order to give a thorough picture of the non-motorized transportation situation in a selected area and evaluate the present condition of the non-motorized transportation systems in Rewa city.

Table 10. Non-motorized transportation facilities

Area	coverage scoring	Access time Scoring	Calculated scoring	Overall score	Descriptor
Neem Tiraha	1	4	5	1	Good
Janta College	1	2	3	1	Good
Stadium Intersection	1	3	4	1	Good
College Square	1	2	3	1	Good

10 GREEN TRANSPORT INDEX ESTIMATION

The Global Walkability Score, the Public Transit Facility Score, the NMT Facility Score, and the Emission and Bio-capacity Score are the four scores that make up this study's Green Transportation Index. These scores would be combined using a weighted index approach to determine the final GTI values for the selected places.

10.1 Index value calculation process

GTI values are calculated using following formula.

$$GTI = \frac{(EBS*W1 + GWS*W2 + PTFS*W3 + NTFS*W4)}{W1 + W2 + W3 + W4}$$

Where; GTI = Green transportation index

EBS = Emission and Bio-capacity score,

GWS = Global walkability score,

PTFS = Public transit facility score,

NTFS = Non-motorize transport facility score;

and W1, W2; W3, W4; are weights for corresponding score.

10.2 GTI for Selected Study Areas

Following the methodology, GTI value for each study area has been estimated. At first using equal weight (Each score has weight of 0.25 out of 1) for the component of the index, GTI values area calculated and presented in Table.

Table 11. GTI values for different study area using equal weight

Area	EBS	GWS	PTFS	NTFS	GTI	Color Code	Descriptor
Neem Tiraha	4	2	3	1	2.5		Bad
Janta College	4	2	3	1	2.5		Bad
Stadium Intersection	3	2	3	1	2.25		Bad
College	3	3	3	1	2.5		Bad

Square							

Here, all four areas has GTI value that is greater than 2- Up to 3. It implies that; transportation condition have no evidence of sustainability concern, carbon uptake is very high, walking condition is less suitable, public and NMT services are in poor condition in these areas, in short overall condition is bad and have the color code of "Dark Yellow".

11. CONCLUSIONS

1. Because of the high demand for daily travel, Rewa's transportation system affects the sustainability and economics of the city in addition to contributing to environmental degradation by releasing carbon into the atmosphere. By incorporating ecological and environmental context into the transportation planning field, this study aims to bridge the gap between conventional transportation planning techniques and sustainable transportation planning in order to identify sustainable transportation options for cities.

2. The study thus develops an index for "Green Transportation," which identifies the problems with the existing system and offers workable solutions by integrating the concepts needed to make the transportation system ecologically sustainable.
By considering walkability, public transportation and non-motorized transportation system facilities, and the amount of carbon dioxide emissions, the study calculates the green transportation index value for the selected study areas. Here, the "Emission and Bio-Capacity" score for carbon dioxide, the "Global Walkability Score" for walkability, and the "Public Transit facility score" and "Non-motorized transportation facility score" for public and non-motorized transportation are developed using the carbon uptake land and bio-capacity analysis based on the Indian service level benchmark. These scores were used to obtain the index values.

3. Decision-makers in Rewa city transit would be greatly impacted by such research. The index value would easily provide a quick summary of the condition of transportation in different places. Consequently, the primary concerns would be really easy for everyone to comprehend. Professionals and non-technical persons alike would benefit from this index's ability to explain the current situation and the need for changes. Additionally, by gaining political support, the proposed strategies would assist the transportation planners in developing new plans and enhancing the execution of existing ones, as they complement the current Rewa transportation plan.
4. This study differs greatly from earlier ones on Rewa's transportation system. Furthermore, given the global context, this study has added unique knowledge for transportation planning. However, there isn't yet an indexing system that might demonstrate how ecologically friendly transportation is while accounting for variations. Every important issue that could come up and be important to environmentally friendly transportation was thoroughly examined in this study. There has never been a study of this kind for a city. Furthermore, the study's methodology integrates several unique approaches from previous research and presents novel approaches based on trustworthy statistical procedures. The study's scale is also unique because it addresses transportation analysis at a mesoscopic level, and further in-depth research can be conducted at a smaller scale.

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