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SHIFT TOWARDS SUSTAINABLE URBAN TRANSPORT: THE CASE OF INDIA

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Abstract: In light of the recent dialogue and growing significance of sustainability, it is evident that the transportation system remains one of the major roadblocks to achieving sustainable growth. Sustainable development - refers to development in the present without compromising the ability of future generations to meet their needs. India is the third largest contributor, accounting for 6.8% of global greenhouse gas emissions, while transportation remains a major contributing sector accounting for 29% of greenhouse gas emissions in 2019. The country suffers from an overloaded transport system that has failed to keep pace with the rapid urbanization and growing population and has thus become heavily congested. The state of urban transport clearly lacks planning while current infrastructure is constantly decaying and in neglect. Reports highly suggest urban planning to be prioritized with due consideration to a hierarchy of needs to optimize the use of time, money and other resources, resulting in highly productive outcomes for the economy. Sustainability of urban transport systems finds alignment with the United Nations' sustainable development goals and is crucial towards promoting sustainability in all spheres to bring about economic growth worldwide. This paper thus, aims to present a framework to examine the level of sustainability or the transport system. The indicator-based framework is used to determine the level of sustainability of the transport system in the city of Delhi, while entailing best practices and policy recommendations to facilitate the same. Secondary data gathered from various journals and publications has been used. The findings indicate Delhi's transportation system to be highly unsustainable and polluting and details suggestions to deal with the same.

I. INTRODUCTION

Sustainability in transport as a concept was introduced in 1992 at the United Nation's Earth Summit, later discussed again in 1997 at the UN General Assembly, the agenda failed to arrest the attention of world economies as a prioritised concern as economic growth continued without much done regarding developing sustainable economies. It was only in 2012, that global attention drew to transport and mobility as the key to achieve sustainable development. Subsequently, at initiation of the then UN General Secretary, policy recommendations of a high level group pertaining to sustainable transport were released at the Global Sustainable Transport Conference in 2016 but what is sustainable transport?

Sustainable Transport - refers to the infrastructure system to meet the mobility needs of a society such that it can be developed, operated and maintained with minimum harm caused to the environment and without compromising the needs of future generations.

Development of such a system encompasses social, economical and ecological aspects, that represent the three pillars of sustainability :

1. **Economic** - Sustainable transport infrastructure costs should be economical, ie: within the ability and willingness of the economy to pay.
2. **Social** - Sustainable transport system must ensure that transportation needs of all are fulfilled, to make sustainable transport system social in true sense, it must be securely accessible to all.
3. **Environmental** - Transport infrastructure can only be sustainable if it minimises pollution and harm caused to the environment.

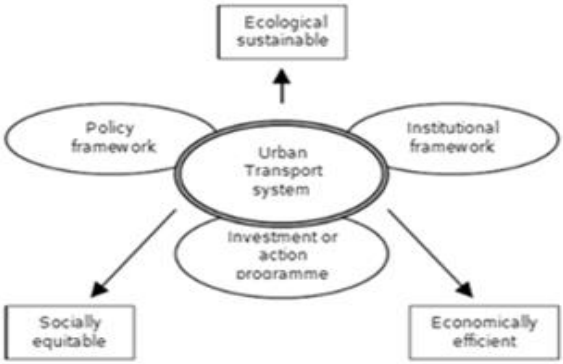

Fig : Conceptual Basis for Sustainable Urban Transport, source : Beella, 2002

II. LITERATURE REVIEW

(Zegras, 2005) examines the role of 'built' environment, ie : environment created through human activities on sustainable mobility. Since sustainable mobility is closely linked to transportation, efforts have been made to evaluate the impact of the 'built' environment on transportation, travel behaviour, vehicle ownership and use. The methodology involves use of several models as a framework to assess sustainability of the city of Santiago de Chile, with help of 2001 household travel survey data. The analytical findings were that loss of personal automobile vehicles would have more negative implications on mobility than loss of metro or bi-cycle. The research finds potential good use for policy makers in the context of urban planning and management of Santiego. The micro-scale built environmental factors having effect on automobile ownership and use could be used for planning and forecasting. The research faced limitations in terms of data availability for forecasting purposes and not taking into account factors in the context of a developing city like : rapid motorisation, new technology, etc.

(Nathan & Reddy, 2011) proposes an MVBB framework for SDI indicators in an urban context. The framework is derived from research of previous literature, modified in the context or transportation sector of Mumbai, and applied to the city. The paper reviewed previous sustainable transport indicator initiatives. In order to formalise the indicators they were classified into : social wellbeing, ecological acceptability and economic efficiency, thus forming parameters to evaluate the transport sustainability of any urban city. The study proposes a total of 54 indicators to form a multi-dimensional view of sustainability of the transport sector that although not a cure by itself, can still help measure the extent of the problem and possible directions to take for resolving it.

(Alam, 2015) provides a critical analysis of Delhi's transportation system with the help of expenditure related data. To improve sustainability the paper proposes development of non-motorised transport. It provides theoretical directions for standards and guidelines to be followed for development of an equitable and sustainable transportation system. Conclusively, the paper remarks the need for planned expenditure, integration of metro and urban bus services and for the government to set up transport service standards.

(Salim & Fernandez, 2015) undertakes a detailed analysis of the aspects and sustainability of urban planning of the city of Delhi. Sustainability is assessed in regard to parameters like : urban form, transport, peak oil, biodiversity, climate change and water management and use. The study also examines challenges or obstacles that present major issues to the city's development in this regard while making suggestions that can be implemented and future vision for the city.

(Thynell, Mohan & Tiwari, 2010) is a comparative paper focusing on best urban transport and sustainability practices in the cities of Delhi and Stockholm by comparing statistics on various parameters from both countries including vehicle ownership, pollution and other data. The findings of the study indicate that modernisation of transport leads to limited sustainability however, it is found that

modernisation of transport has been favoured at the cost of sustainability in these cities and that it is Delhi can be made potentially more inclusive than Stockholm with respect to urban transport.

III. OBJECTIVES

I. To present an indicator-based framework to evaluate sustainability of the transport system of Delhi.

II. To apply the given framework to examine sustainability of Delhi's transportation system.

III. To suggest policy recommendations to facilitate better urban planning and development of sustainable transport infrastructure for the city of Delhi.

IV. RESEARCH METHODOLOGY

The research has been carried out using secondary data. A comprehensive review of literature to determine a suitable sustainability framework in context of data available was undertaken. SUTI framework developed by UNESCAP has been chosen for the given study, comprising 10 sustainability indicators that have been duly recognised as relevant. Due to data availability constraints, sustainability of the transport system of Delhi has been assessed across each parameter to give a final verdict and suggest policy recommendations based on the same. All data has been gathered from credible sources and suggestions have been made after careful study of existing literature.

V. FRAMEWORK

The United Nations Economic and Social Commission for Asia and the Pacific, in order to assess sustainability of urban transport systems in cities has developed a reliable indicator based framework to summarize, track and compare the performance of urban transport systems and how sustainable they are. The 10 indicator based framework is called Sustainable Urban Transport Index or (SUTI).

No.	Indicators	Natural units	Weights	Normalization	
				MIN	MAX
1	Extent to which transport plans cover public transport, intermodal facilities and infrastructure for active modest	0 - 16 scale	0.10	0	16
2	Modal share of active and public transport in commuting	Per cent of trips/mode share	0.10	10	90
3	Convenient access to public transport service	Per cent of the population	0.10	20	100
4	Public transport quality and reliability	Per cent of satisfied with service	0.10	30	95
5	Traffic fatalities per 100,000 inhabitants	No of fatalities	0.10	35	0
6	Affordability – travel costs as part of income	Per cent of income	0.10	35	3.5
7	Operational costs of the public transport system	Cost recovery ratio	0.10	22	175
8	Investment in public transportation systems	Per cent of total investment	0.10	0	50
9	Air quality (PM10)	µg/m3	0.10	150	10
10	Greenhouse gas emissions from transport	Tons	0.10	2.75	0
			1.0		

Table : Overview of SUTI indicators, source: Regmi, 2017.

Shown above are the 10 indicators, measured on different scales with minimum and maximum values specified for each scale. Each of the indicators in calculation of the final index score have been given equal weights of 0.1.

VI. Calculation

Each of the indicators measured on different scales need to be normalized before calculation. The method of linear re-scaling for composite index is used. Transforming all indicator values to a 1-100 scale. It uses the following formula:

$$Z_{i,c} = \frac{(X_{i,c}) - (X_{min,i})}{(X_{max,i}) - (X_{min,i})} * 100$$

Where, Z - is normalised indicator for topic x, city c

X_{min} is the lowest value of the indicator, X_{max} is the highest value of the indicator

Finally, before calculating the index score, it is important to assign weights to the indicators to be used. Since sustainability theory suggests that each parameter has equal importance in sustainable decision-making, the framework assigns equal weight of 0.10 to all indicators, irrespective of their domain.

Final index value can be calculated using two approaches, the arithmetic mean or geometric mean. Arithmetic mean involves addition of value of each component divided by the total number of components ie: 10. However, geometric mean is the preferred approach and can be calculated based on the following formula:

$$SUTI = \sqrt[10]{i1 * i2 * i3 \ldots * i10}$$

Based on the calculation, a spider-web diagram can be created as part of the framework, indicating city performance with respect to min and max values of each of the indicators. It facilitates instant visual comprehension of the city's urban transport systems's performance in the context of sustainable development.

VII. DATA ANALYSIS

Indicator	Unit of Measurement	Value
Extent to which transport plans cover public transport, intermodal facilities & infrastructure for active modest	0-16 scale	-
Modal share of active and public transport in commuting	Trips/mode share	60%
Convenient access to public transport and service	% of population	60%
Public transport quality and reliability	% satisfied	-
Traffic fatalities per 100000 inhabitants	No. of fatalities	140
Travel costs as part of income (Affordability)	% of income	19.50%
Operational costs of public transport system	Costs recovery ratio	0.5
Investment in public transportation systems	% of total investment	13.60%
Air quality (PM10)	µg/m^3	138
GHG emissions from transport	CO2 Eq tonnes/capita/year	32%

Source : Transport surveys and research publications

Due to data availability constraints, data for eight indicators has been obtained, through transport surveys of Delhi Metro Rail Corporation, Economic Survey of Delhi and research publications from various authors. Moreover, the SUTI framework mentions min and max values for indicators based on an average for Asian cities. Based on data collected for the city of Delhi, it is clear that the framework would need to be modified for use as the data fails to fall in the specified range. Due to limits placed as a result on the nature of research and resources, use of the SUTI framework is beyond the scope of this study. However, the data collected is benchmarked against standard indicator values for a developed country like the USA and best performing Indian state in that category, followed by a qualitative review. This allows for evaluation of sustainability across each parameter for the city of Delhi, the results for which are as follows:

VIII. FINDINGS

1. **Extent to which transport plans cover public transport, intermodal facilities and infrastructure for active modest** - Based on a qualitative review of the city's transport plan, it is found that Delhi's transport plan is extensive and covers wide range of places for commute. It is one of the most extensive and well-connected transport networks in the country.
2. **Modal share of active and public transport in commuting** - The modal share of active and public transport in commuting shows the split between private and public transport being used in the city. Although 60-70% of the population is dependent on public transport for commute, it has been observed that the modal split for private transport has been increasing over the years perhaps due to dissatisfaction with public transport services while the modal share of public transport has been consequently declining from 75% in 200-2001.
3. **Convenient access to public transport and service** - Centre for Science and Environment's survey reveals that 40% of Delhi's population does not have access to bus stops within 500m while 69% do not have access to metro stations within 500m.
4. **Public Transport Quality and Reliability** - Based on DMRC's survey it is found that 70% of passengers are highly satisfied with Delhi metro services. However, since the metro services do not account for other modes of public transport and inadequacy of data available otherwise, the figure could not be included for analysis.
5. **Traffic fatalities per 100000 inhabitants** - The road fatality rate in Delhi is seen as high compared to developed countries in the world and even best performing states in India, where the numbers can be seen in even single or double digits. Not only this, but the fatality rate has been constantly increasing over the past years, indicative of a congested transport system.
6. **Affordability** - Households spend about 19% of their monthly income on public transport in Delhi. The figure is not ideal and steps need to be taken to make public transport in Delhi more affordable to the public.
7. **Operation costs of public transport system** - Measured by the farebox recovery ratio that has shown a declining trend since 2011 and has recently fallen to 50%. Compared to developed countries that manage to recover the whole or above the whole cost of operating transport infrastructure Delhi seems to be far behind. As the National Capital, it is expected to take the lead in transport development and thus, must look for ways to improve the recovery ratio paving way for a better transport system in India.

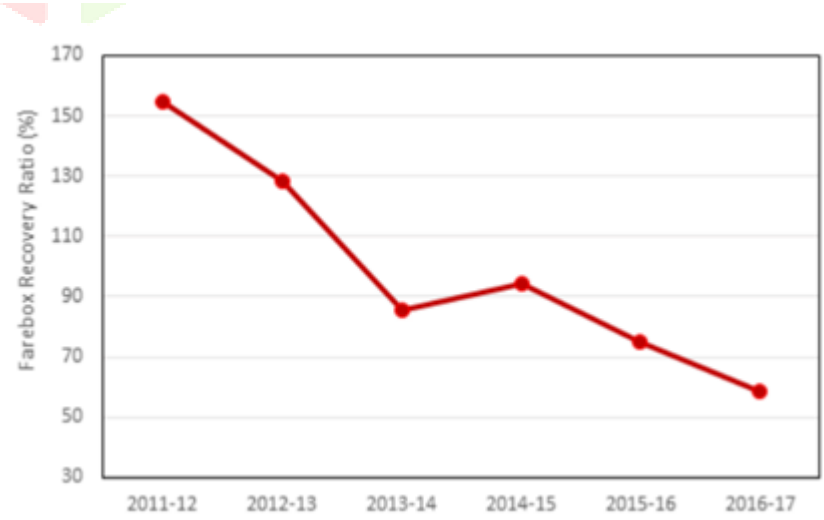

Fig : Declining farebox recovery ratio in India, source : Centre for Financial Affordability, Financial Assessment of Delhi Metro

8. **Investment in public transportation systems** - The proposed allocation of investment in transport infrastructure in Delhi government's budget 2020-2021 is 13.6%. While the figure is generous, the investment needs to be made strategic to prevent unrecovered costs and unproductive expenditures.
9. **Air quality -** The air quality in Delhi remains unhealthy with a level of pollution beyond 100. The air quality has been a major cause for concern over the past few years, however, none of the efforts in bringing it down so far have succeeded.
10. **GHG Emissions -** According to reports, 32% of the city's greenhouse gas emissions come from the transport sector. As India strives to fight against climate change and develop an environmentally responsible economy, it is imperative that emission levels be controlled, especially if the aim is to develop a sustainable urban transport system.

IX. POLICY RECOMMENDATIONS

1. Aim at creation of multi-modal transportation system
2. Setting up a metropolitan transport fund to overcome financial bottlenecks for infrastructural development to overcome dependency on private transport
3. Development of 15-minute neighbourhoods, ie: an immediate neighbourhood wherein destinations at a 15 minute distance are well connected to only favour walking means of transport while neighbourhood as a whole is connected to an advanced transport system.
4. Setting up long-term transport infrastructure plans rather than short-term ones.

X. CONCLUSION

Based on analysis and findings of above mentioned data, we can conclude that Delhi transport system is unsustainable based on a number of factors. While it does well in covering a large extent, in resolving public dependency on transport and recovering operation costs, other equally important parameters are lagging behind. The state of urban transport systems in major metropolitan cities of India like Delhi, Bangalore, etc is far from sustainable. It is imperative that these concerns occupy a priority in the government's plans and several substantial steps be taken in this direction to mitigate issues like travel demand, travel supply and to decarbonize the systems.

XI. FUTURE SCOPE

The work in this paper can be furthered by undertaking an expert based study for calculating the SUTI for the city of Delhi. Previous such undertakings have been carried out for the city of Bhopal in India. Since evaluation of SUTI framework for the city of Delhi remains unconducted but is highly relevant the study has a lot of scope for future study for various purposes like urban planning, research purposes and policy development.

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