Comparative Performance Evaluation of Alternate Public Transport System

Jitendra Gurjar[1*], P. K. Agarwal[2], P. K. Jain[3]

[1]Ph.D. Scholar & Contract Faculty, Department of Civil Engineering, Maulana Azad National Institute of Technology, Bhopal, India

[2]Professor, Department of Civil Engineering, Maulana Azad National Institute of Technology, Bhopal, India

[3]Professor & Head, Department of Civil Engineering, Maulana Azad National Institute of Technology, Bhopal, India

Abstract: Recently various public transport systems like bus rapid transit (BRT) system, light rail transit (LRT) system, mass rapid transit (MRT) system, and many more public transport systems are running in various Indian cities. It is observed that huge investment is required for implementation of this public transport system in Indian cities. Hence, the significant explanations for determination of comparative performance of alternate public transport system from user aspect are to maintain expenses, and justify the adjustments in system before its implementation. Along these lines there is critical need to intelligent investigation is required to examination of comparative execution of alternate public transport system from user perspective. Subsequently, this study displays a methodological structure for comparative execution of alternate public transport system in Indian urban areas considering user point of view. It is expected that this structure will be helpful to comparative assessment of performance of public transport system from user perspective in Indian context.

Keywords: Public Transport System, User Perspective, Key User Performance Indicator, Comparative Performance Evaluation

I. INTRODUCTION

Public transport system in Indian cities must be more creative and attractive due to higher dependency of urban population. Recently various public transport systems like bus rapid transit (BRT) system, light rail transit (LRT) system, mass rapid transit (MRT) system and many more public transport systems are running in various Indian cities. It is observed that the enormous amount of money is required for implementation of this public transport system in Indian cities. Hence, the significant explanations for determination of comparative performance of alternate public transport system from user aspect are to maintain expenses, and justify the adjustments in system before its implementation. Presently a-days a large portion of the operators have its own technique to know the execution of public transport system. In any case, the performance assessments by the operators don't as a matter of course mirror the user viewpoint and can't be viewed as sufficient. Further, because of truant of information base the vast majority of the studies may not be sufficient for examining the performance of alternate public transport system from user point of view. Subsequently, this study exhibits a balanced structure which can assess the comparative performance of alternate public transport system from user point of view with insignificant information which are accessible effectively at least taken a toll. The four noteworthy stages comprise of proposed methodological structure. The first stage is to identify the most appropriate key user indicators for comparative performance evaluation of alternate

public transport system in Indian context. The second stage develops a methodology to evaluation of condition of identified key user performance indicators. The relative weight of identified key user performance indicators are determined using Fuzzy AHP method in third stage. In last stage comparative user performance index (CUPI) is developed which indicate the overall comparative performance of alternate public transport system from user perspective. This paper comprises of four section among this is the one which presents background of the study. The second section highlights the need of study. A fundamental structure for comparative performance of alternate public transport system from user point of view is exhibited in section three. The last section exhibits the essential conclusions drawnbased on this study.

II. LITERATURE REVIEW

A critical review of the literature was carried out on performance indicators used worldwide previously and various criteria of their selections, and use ability with the context of Indian cities. Performance indicator is a performance tool which can be used to report the performance status of public transport system to decision makers. Gandhi et al [1] studied that user performance indicators play a prominent role in determining whether a system is used. It is observed that a large number of indicators available in literature **{**MOUD, [2], Tumkur city bus evaluation report **[**3], Abreha [4]; TRB [5]; Eboli & Mazzulla [6]; Niyonsenga [7]; Morfoulaki M. et al [8]**}** for performance evaluation of public transport system from user perspective. Hook et al [13] discussed that the selection of performance indicators is often based on its end use and the availability of measurable or observable data. Mistretta M. et al [9] said that in most of evaluation methodology developed performance indices will not have any comparisons of services to identify necessary changes needed to provide more effective service. Limited methodologies {Gandhi et.al, [1]; Agarwal et al [10], Roux Y. E. et.al, [11]; Sezhianet.al, [12],} are available on comparative performance evaluation of public transport system. Agarwal P. K. et al [13], Khasnabis S. et al [14] and Pticina I. [15] discussed that in practice it may be much more complicated to obtain the necessary comparative information about existing public transport system using these indices due to absence of data base. Hence, critical review of the literature indicated that there is need to develop a simple methodology from user point of view which can evaluate the comparative performance of alternate public transport system with minimal data.

III. FRAMEWORK OF PROPOSED METHODOLOGY

This study presents a basic fundamental structure for comparative performance evaluation of alternate public transport system from user perspective. A basic framework of a methodology is presented in Figure 1.

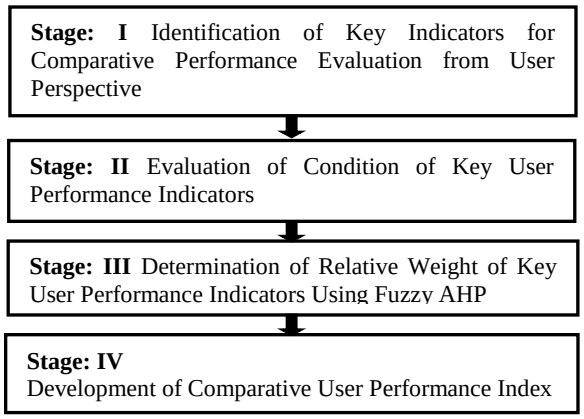

Figure 1: A Basic Framework for Comparative Performance Evaluation from User Perspective

The proposed methodological framework can be used to evaluating the comparative performance of an existing public transport system as well as a new public transport system to any similar system or different public transport system from user perspective. The proposed framework consists of major four stages. The details of major stages are presented in subsection of this section as follows

*A. **Stage I: Identification of Key Indicators for Comparative Performance Evaluation from User Perspective***

The purpose of the first stage is to identify the most appropriate key performance indicators which are affecting the comparative performance of alternate public transport system from user perspective in India context. The classification of key performance indicators from user perspective is a complicated task because many indicators are available in literature and there is no comprehensive classification. Therefore, this study developed a hierarchical structure logically on the basis of literature review to selection of most significant indicators from Indian context and availability of data. A hierarchical structure for identification of key user performance indicators is presented in Figure 2.

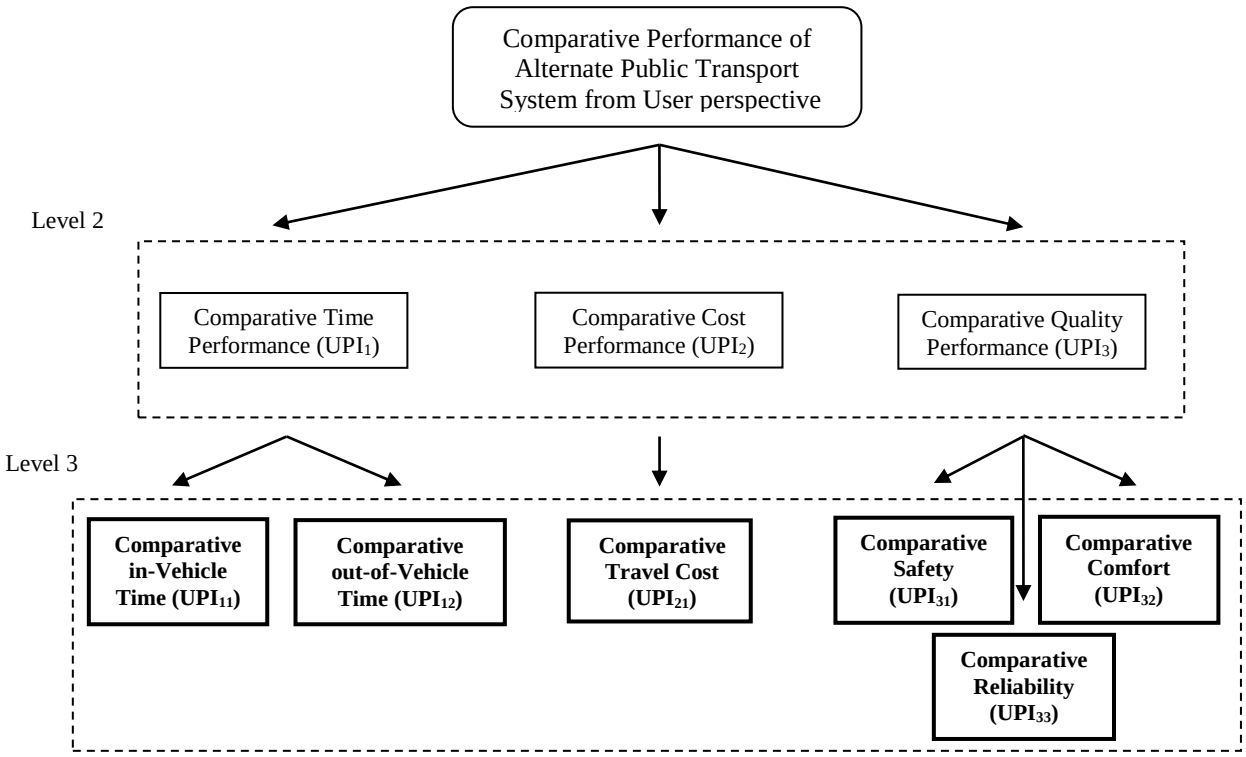

Figure 2: A Hierarchical Structure for Identification of Key User Performance Indicators.

The highest level of the hierarchy is the overall goal of the methodology. The second level represents the three major criteria i.e. comparative time performance, comparative cost performance and comparative quality performance. Further at third level these major criteria decomposed in 6 key user performance indicators, four (UPI_{11}, UPI_{12}, UPI_{21}, UPI_{33}) of them are quantitative indices and the remaining two (UPI_{31}, UPI_{32}) are qualitative indices.

B. Stage II: Evaluation of Condition of identified Key User Performance Indicator

The second stage are developed various important indices in such a way so that comparative performance of alternate public transport system can be evaluated in Indian cities from user perspective with minimal data. The value of indices greater than one, equal to one and less than one indicates the comparative performance of alternate public transport system 1 is superior, equal and inferior quality with respect to alternate public transport system 2. Table 1 presents a methodology for evaluation of condition of identified key user performance indicators.

Table 1: Methodology for Evaluation of Condition of Identified Key User Performance Indicators.

ID	Key User Performance Indicator	Methodology for Evaluation of Condition of Identified Key User Performance Indicators
UPI_{11}	Comparative in Vehicle Time Index **(CITI)**	$CITI = \frac{ATT_2}{ATT_1}$ equation - 1 ATT_1 = Average travel time per km in vehicle in minute for alternate public transport System1 ATT_2 = Average travel time per km in vehicle in minute for alternate public transport System 2 $ATT_{1/2}$= (60*ARL)/AOS ARL = Average Route length in km AOS = Average operational speed in kmph
UPI_{12}	Comparative out of vehicle Time Index **(COTI)**	$COTI = \frac{AOT_2}{AOT_1}$ equation - 2 AOT_1 = Average out of vehicle time in minute for alternate public transport System1 AOT_2 = Average out of vehicle time in minute for alternate public transport System 2 Average out of vehicle time= Average Waiting time at stop (WTT) + Average transfer time from origin to stop and stop to destination. (TFT) WTT=(60/NVR) in minute NVR=No of vehicles reached at stop per hour
UPI_{21}	Comparative travel Cost Index **(CTCI)**	$CTCI = \frac{ATC_2}{ATC_1}$ equation - 3 ATC_1 = Average travel cost per km for alternate public transport System 1 ATC_2 = Average travel cost per km for alternate public transport System 2
UPI_{31}	Comparative Safety Index	$CSFI = \frac{SRT_1}{SRT_2}$ equation - 4

(CSFI)

SRT_1 = Safety rating given by users during travel in vehicle and waiting at stop for alternate public transport System 1

SRT_2 = Safety rating given by users during travel in vehicle and waiting at stop for alternate public transport System 2

$SRT_{1/2}$ == $(5*R_5+4*R_5+3*R_5+2*R_2+1*R_1/(5*TNR)$

TNR=Total no of respondent=R5+R4+R3+R2+R1

R5= No of respondent feel extremely safe during travel in vehicle and waiting at stop (5), R4= No. of respondent feel good safe during travel in vehicle and waiting at stop (4), R3= No. of respondent feel average safe during travel in vehicle and waiting at stop (3), R2 = No. of respondent feel safe to some extent during travel in vehicle and waiting at stop (2), R1 = No. of respondent feel not at all safe during travel in vehicle and waiting at stop (1)

UPI_{32} Comparative Comfort Index

(CCFI)

$$CCFI = \frac{CRT_1}{CRT_2}$$ equation - 5

CRT_1=Comfort rating given by users during travel in vehicle and waiting at stop for alternate public transport System 1

CRT_2 =Comfort rating given by users during travel in vehicle and waiting at stop for alternate public transport System 2

$CRT_{1/2}$ = $(5*R_5+4*R_5+3*R_5+2*R_2+1*R_1/(5*TNR)$

TNR=Total no of respondent=R5+R4+R3+R2+R1

R5= No of respondent feel extremely comfort during travel in vehicle and waiting at stop (5), R4= No. of respondent feel good comfort during travel in vehicle and waiting at stop (4), R3= No. of respondent feel average comfort during travel in vehicle and waiting at stop (3), R2 = No. of respondent feel comfort to some extent during travel in v travelling in vehicle and waiting at stop (2), R1 = No. of respondent feel not at all comfort travel in vehicle and waiting at stop (1)

UPI_{33} Comparative Reliability Index

(CRBI)

$$CRBI = \frac{ARB_1}{ARB_2}$$ equation - 6

ARB_1 = Average Reliability of vehicle at stop for alternate public transport System 1

ARB_2 = Average Reliability of vehicle at stop for alternate public transport System 2

$ARB_{1/2}$=NOT/TNT

NOT= No. of trips on time on the stop in a route

TNT= Total no. of trips in same route

C. Stage III: Determination of Relative Weight of Key User Performance Indicators Using Fuzzy AHP

The identified indicators may not be equally affecting overall comparative performance of alternate public transport system from use perspective. Therefore, relative weight of key user performance indicators are determined by Fuzzy AHP method using passengers and transport expert opinion survey. The relative weight obtained from Fuzzy AHP method is presented in Figure 3.

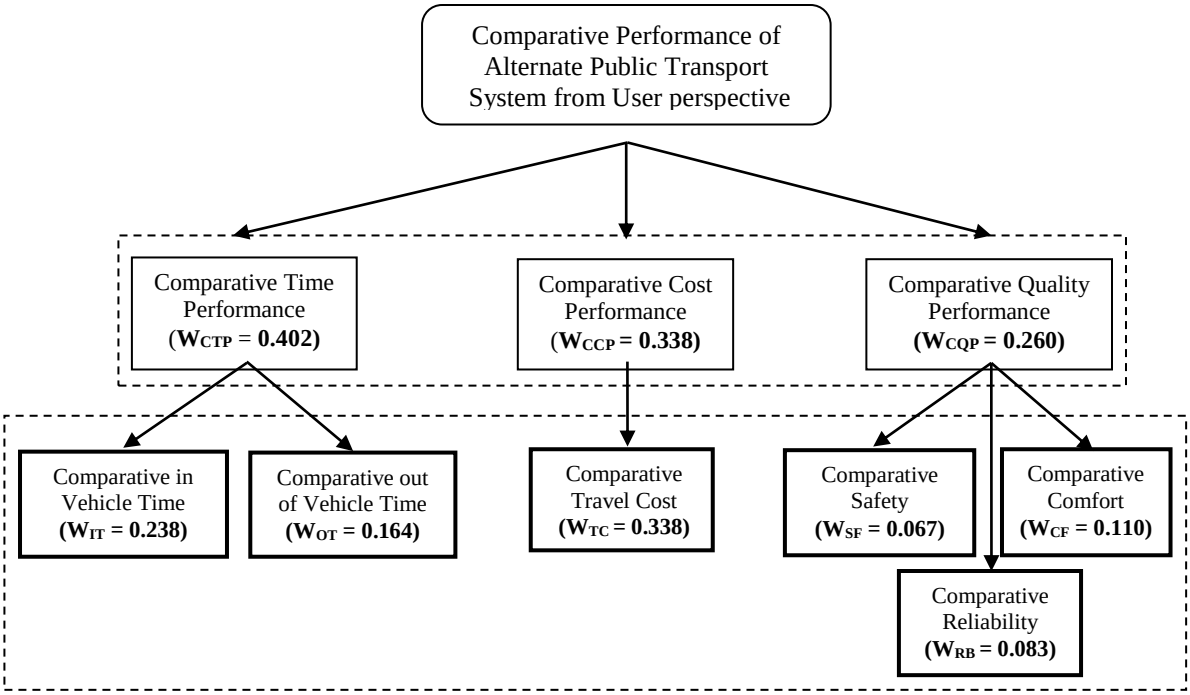

Figure 3: Relative Weight of Identified Key User Performance Indicators

D. Stage IV: Development of Comparative User Performance Index (CUPI)

Comparative user performance index (CUPI) is developed in this stage which indicates the comparative performance of alternate public transport system 1 with respect to alternate public transport system 2 from user perspective. The comparative user performance index (CUPI) is evaluated using equation (7).

$$CUPI = W_{CTP}*CTPI + W_{CCP}*CCTI + W_{CQP}*CQPI \quad (7)$$

Where, W_{CTP}, W_{CCP} and W_{CQP} are relative weight of respective comparative time performance comparative cost performance and comparative quality performance of public transport system as discussed earlier. The equation (7) can be written as equation (8) after putting the value of weight.

$$CUPI = 0.402*CTPI + 0.338*CCTI + 0.260*CQPI \quad (8)$$

Comparative Time Performance Index (CTPI)

Comparative time performance index which are depends upon comparative time in a vehicle and comparative time out of vehicle and which can be evaluated using equation (9)

$$CTPI = W_{IT}*CITI + W_{OT}*COTI \quad (9)$$

Where, W_{IT} , and W_{OT} are relative weight of respective comparative in vehicle time and comparative out of vehicle time of public transport system as discussed earlier. The equation (9) can be written as equation (10) after putting the value of weight

$$CTPI=0.238*CITI+0.164*COTI \quad (10)$$

Comparative Cost Performance Index (CCPI)

Comparative cost performance index which are depends upon comparative cost during travelling in a vehicle and which can be evaluated using equation (11)

$$CCPI=W_{TC}*CTCI \quad (11)$$

Where, Where, W_{TC} is relative weight of respective comparative travel cost of public transport system as discussed earlier. The equation (11) can be written as equation (12) after putting the value of weight

$$CCPI=0.338*CTCI \quad (12)$$

Comparative Quality Performance Index (CQPI)

Comparative quality performance index which are depends upon comparative comfort, comparative safety and comparative reliability during travelling in a vehicle and waiting time at stop and which can be evaluated using equation (13)

$$CQPI=W_{SF}*CSFI+W_{CF}*CCFI+W_{RB}*CRB \quad (13)$$

Where, W_{SF}, W_{CF} and W_{RB} are relative weight of respective comparative safety, comparative comfort and comparative reliability of public transport system as discussed earlier. the equation (13) can be written as equation (14) after putting the value of weight

$$CQPI=0.067*CSFI+0.110*CCFI+0.083*CRBI \quad (14)$$

Thus, it is expected that this indices will be valuable to assessing the comparative performance of an existing public transport system addition a new public transport system to any similar system or different public transport system from user perspective in Indian context.

IV. CONCLUSIONS

The main objective of this study is to present a basic framework for comparative performance of alternate public transport system in Indian cities. The imperative conclusions drawn from this study are as per the following:

- Literature survey showed that because of missing of information base the majority of the studies may not be satisfactory for investigating the comparative performance of alternate public transport system from user point of view. Subsequently, there is need to develop a straight forward approach which can assess comparative performance of alternate public transport system from user point of view and also, works significantly with quantifiable and insignificant information.

- This study proposes a simple methodology for comparative performance of alternate public transport system in Indian cities. The proposed methodological framework consists of four major stages are as follows:

    - Stage I of this study identified three major criteria i.e. comparative time performance,

comparative cost performance and comparative quality performance. Further these major criteria decomposed in 6 key user performance indicators i.e. comparative in vehicle time, comparative out of vehicle time, comparative travel cost, comparative safety, comparative comfort, and comparative reliability

- Various important indices for evaluation of condition of identified key user performance indicators are developed in stage II. These indices are developed in such a way so that compare the performance of two different or same public transport systems from user perspective with minimal data.

- Stage III of this study determines the relative weight of comparative in vehicle time, comparative out of vehicle time, comparative travel cost, comparative safety, comparative comfort and comparative reliability are 0.238, 0.164, 0.338, 0.067, 0.110 and 0.083 respectively which are represent the relative contribution in comparative performance evaluation of alternate public transport system.

- Comparative time performance index, comparative cost performance index and comparative quality performance index are developed in last stage in such a way so that comparative performance of alternate public transport system can be evaluated separately from time, cost and quality aspect. This study also developed comparative user performance index (CUPI) which can be used to indicate the overall comparative performance of alternate public transport system from user perspective.

It is expected that this study will be useful to decision makers to take significant decisions before implementation of new public transport system, alteration of existing system.

Conflict of Interest: The authors declare that they have no conflict of interest.

Ethical Statement: The authors declare that they have followed ethical responsibilities

REFERENCES

[1] Gandhi S., Tiwari G., Fazio J. (2013). Comparative Evaluation of Alternate Bus Rapid Transit System (BRTS) Planning, Operation and Design Options. Proceedings of the Eastern Asia Society for Transportation Studies, Vol.9.
[2] Ministry of Urban Development (2009); "Service Level identified performance indicators Benchmarks for Urban Transport", Ministry of Urban Development (MOUD) New Delhi, Government of India.
[3] Tumkur City Bus Service Evaluation Report" Directorate of Urban Land Transport February, (2013)
[4] Abreha, D. A., (2007). Analyzing Public Transport Performance using Efficiency Measures and Spatial Analysis; the case of Addis Ababa, Ethiopia, Enschede, Netherlands: International Institute for Geo-Information Science and Earth Observation, University of Twente.
[5] Transportation Research Board; (2003). A Guidebook for Developing A Transit Performance Measurement System. A Transit Cooperative Research Program (TCRP) Report No. 88. National Research Council, Washington, DC.
[6] Eboli, L., & Mazzulla, G., (2012). "Performance Indicators For an Objective Measure of Public Transport Service Quality", European Transport, Vol. 51, pp. 1–21.
[7] Niyonsenga, D., 2012. Assessing Public Transport Supply for Kigali, Rwanda, Enschede, the Nederlands: Faculty of Geo-Information Science and Earth Observation, University of Twente.

[8] Morfoulaki, M., Tyrinopoulos, Y. & Aifadopoulou, G., (2007). Estimation of Satisfied Customers in Public Transport Systems : A New Methodological Approach. , Journal of the Transportation Research Forum, Vol. 46, No. 1 pp. 63-72.

[9] Mistretta, M., Goodwill, J. A., Gregg, R. and DeAnnuntis,C.,(2009). "Best Practices in Transit Service Planning," Final Report Prepared by Transportation Research Centre, Florida, March 2009.

[10] Agarwal P.K., Gurjar J., Gautam A., Jain P.K., (2015). "A Rational Methodology for Evaluation of the Impact of Public Transit Service in a City," International Journal of Frontier in Technology, Vol. 2, No.2, 18-25.

[11] Roux, Y.E.,Del Mistro, Romano F., Mfinanga D. (2011). A methodology for comparative analysis of public transport systems in African cities. Proceedings of the 30th Southern African Transport Conference (SATC)

[12] Sezhian V.M., Muralidharan C., Nambirajan T., Deshmukh S.G., (2011). Performance measurement in a public sector passenger bus transport company using Fuzzy Topsis, Fuzzy AHP and ANOVA-A case study. International journal of engineering and technology (IJEST), Vol.3 No. 2,pp. 1046-1059.

[13] Agarwal P.K., Gurjar J., Gupta V (2016). Evaluation of Socio-economic Impact of City Bus Services in Developing Countries. Accepted in WCTR Conference for Possible Publication in Transportation Research Procedia 10-15 July Shanghai, China.

[14] Khasnabis, S., Emadeddin A., Libo Liu; and Richard Darin Ellis (2003). Comparative Study of Two Techniques of Transit Performance Assessment : AHP and GAT. Journal of Transportation Engineering, Vol. 128, No. 6, November 1, 2002. © ASCE pp. 499–508.

[15] Pticina, I., (2011). "The Methodology of Data Collection about Public Transport Service Quality," Proceedings of the 11th International Conference "Reliability and Statistics in Transportation and Communication" 19–22 October 2011, Riga, Latvia, p. 155-164.

