Review on Public Transport Accessibility Level of an Urban Area

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Abstract: Accessibility denotes population's capability to reach goods, services and activities, which is the eventual aim of most transportation system. It is extensively used to assess the efficiency of urban transport network. Assessment of public transport accessibility is used to enhance the feasibility of public transportation system in a urban area. It is a competent way to reduce the external expenditures and unwanted reactions of motorized commuting. To provide better access to activity locations and opportunities, a fair distribution of transportation resources is key, especially considering low income and socially disadvantaged people who depend on public transit. The accessibility indices can be used to suggest recommendation for future public transport system improvement. A GIS mapping tool can be used for visual representation of public transport accessibility of different public transport modes of an urban area.

IndexTerms: **Accessibility, GIS, Public Transport, Urban Area**

I. INTRODUCTION

Public transport is a key part of national and regional transportation infrastructure, and aims to provide accessibility to jobs, health care, and other activities. Heavy traffic congestion is one of the biggest problems that is faced by everyone in each city. Public transportation, while maybe not as pleasant as travelling in private vehicle, does ease congestion, reduce emissions. The imperishable cities associate five conventions of viability for communal transport system: accessibility; affordability; connectivity; land use planning; and planning with the environment in mind.

Access to activity locations is one of the main roles of the public transit. However, with diverse land-use types, accessibility level varies and not all residents benefit equally from public transit. To provide better access to activity locations and opportunities, a fair distribution of transportation resources is key, especially considering low income and socially disadvantaged people who depend on public transit. Accessibility is the ultimate aim of most transportation network; urban transport planning should be based on accessibility. Accessible public transport is assimilation of travel information, walking to bus stop, waiting for bus, boarding to bus, travelling in bus, alighting from bus and walk to destination as shown in Fig. 1

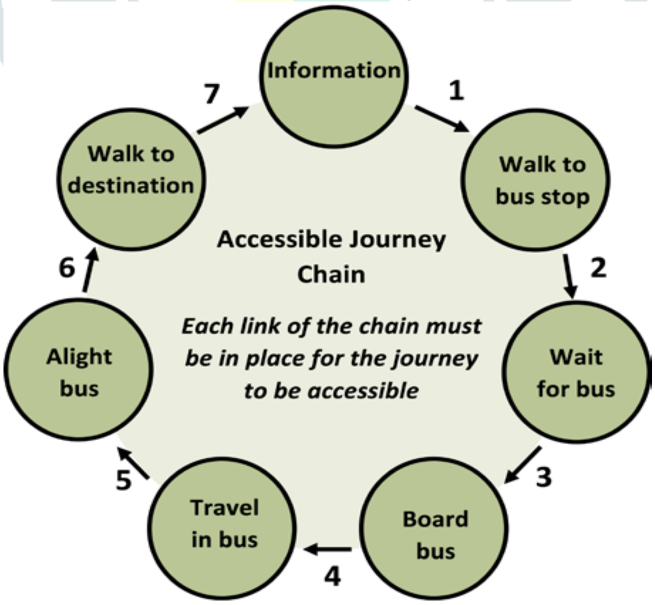

Fig. 1 Accessibility Chain

(Source: Tyler, 2002)

The original idea of measuring accessibility is generally attributed to Hansen (1959). Accessibility evaluation can be clustered into five groups: travel-cost method, constraints-based method, gravity or opportunities method, composite method and utility based surplus method. The gravity or opportunities method concludes the accumulative prospects and gravity models. The constraint method is corresponding to spatial and temporal measures, while the utility surplus method uses the utility procedures with a superior emphasis on discrete behavior and decision making. Composite method attempts to association of temporal-spatial and utility indices into a common model. Accessibility involves mainly three elements; accessibility to stop/station, accessibility to vehicle and accessibility to the service as shown in Fig. 2.

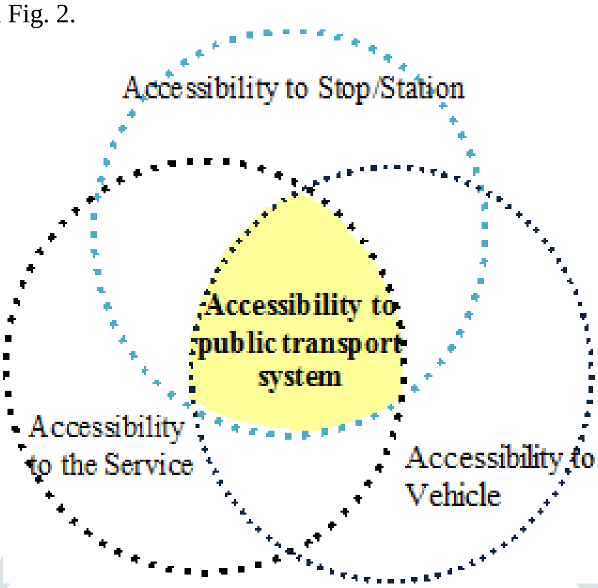

Fig. 2 Elements of the Accessibility to Public Transport System

(Source: Vu Anh TUAN and Duong Thanh SON, J-STAGE Vol. 11, 2015)

The Local Index of Transit Availability (LITA, Rood, 1998) access the intensity of travel service area considering population and size of an area. It measures both spatial and temporal accessibility using service frequency, vehicle capacity and route coverage. The Transit Capacity and Quality of Service Manual (TCQSM, TRB 2003) measures time-space bus stop transit accessibility using service exposure, service regularity, statistic data and service hours. The Time-of-Day tool (Polzin et al. 2002) evaluates spatial and temporal accessibility to transit utility using utility exposure, time of day, waiting period, utility regularity, statistic data and gives the relative value of accessibility for definite time period. The analysis and understanding of data from various sources make this tool more tough to appliance and needs professional transportation personnel to perform this study. The transit level-of-service (Ryus et al.2000) measures spatial and temporal accessibility of pedestrian path connected to transit stops. It considers resident concentration and work concentration with different spatial and temporal aspects using service coverage, time of day, walking paths, service regularity and statistic data. The Transit Service Indicator (TSI, Fu et al., 2005) access accessibility to transit network by comparing different temporal indicators based on O-D approach using service frequency, route coverage and hours of service. The Transit Accessibility Measure (TAM, Bhat et al., 2006) uses comfort & parking, service frequency, access distance, travel time, service hours, network connectivity and vehicle capacity to evaluate accessibility.

The public transport accessibility level (PTAL) evolved in 1992 by London Borough of Hammersmith and Fulham (Cooper 2003, Gent and Symonds 2005). PTAL evolve concentration of the public transport network at a particular point (origin), using service frequency, service coverage for all accessible approaches of conveyance from that point. There are mainly seven steps involved in PTAL methodology,

STEP 1: Define points of interest (POI) and service access points (SAP)

STEP 2: Calculate walk access time (WT) from POI to SAP

STEP 3: Identify valid routes at each SAP and calculate average waiting time (AWT)

$AWT = (0.5*60)/f + K$ ………… (1)

Where, f is hourly frequency and K is reliability factor.

STEP 4: Calculate minimum total access time (TAT) for each valid route at each SAP

$TAT = WT + AWT$ …………… (2)

STEP 5: Convert TAT into equivalent doorstep frequency (EDF)

$EDF = 30/TAT$ ………… (3)

STEP 6: Obtain the accessibility index (AI)

AI for a transport mode (m),

$AIm = EDF_{max} + 0.5 * \Sigma\ EDF$ ………… (4)

AI for a POI,

$AI_{POI} = \Sigma\ AI_{m1}$ ………… (5)

STEP 7: Mapping of AIs obtained for each POI into eight bands of PTAL as shown in Table 1.

Table 1 Accessibility Levels as per London PTAL Methodology

Accessibility Level	PTAL Range	Map Colour	Remark
1a (Low)	0.01-2.50		Very Poor
1b	2.51-5.00		Very Poor
2	5.01-10.00		Poor
3	10.01-15.00		Moderate
4	15.01-20.00		Good
5	20.01-25.00		Very Good

6a	25.01-40.00		Excellent
6b (High)	40.01+		Excellent

(Source: Transport for London (2010), Table 3, p. 6)

II. Literature review

Rui Liu, Yun Chen, Jianping et al. (2018) [8]; A model is developed to evaluate the spatial accessibility of Shanghai Hongqiao Transportation Hub (SHTH) and its adjacent area with considering several transportation modes. The study area is about 450 km^2 which is approximately 7% of the entire area of Shanghai. A theoretical model under some hypothesis, followed by a data acquisition procedure is carried out from three approaches: demographic data, spatial data and questionnaire survey. Then, the study area was divided into 621 grid cells. Primary data were acquired from questionnaire survey and secondary data were from statistics. There are four designed scenarios are derived: Overall scenario, Bus- Metro scenario, Metro-Metro scenario, and Non-transfer scenario. The Total traveling time from each grid cell to transportation hub was determined using ArcGIS software. Accessibility related with all four scenarios were evaluated and mapping of accessibility index.

Asif Raza and Ming Zhon (2018) [1]; explores the influential aspects for transit travel demand by bus and subway in Wuhan, China. The study area is divided into 690 Traffic Analysis Zones (TAZs). Walk speed is assumed as 2.8 km/hr. An origin-destination matrix is developed using ArcGIS software. The research is primarily concerned with two concepts: accessibility and equity. The comparative analysis of various household income levels and area types enable a better understanding of which are offers greater geographic equity of accessibility. The aim of this study is to measure the current supply and demand for public. To measure the accessibility, a gravity model, developed by Hansen is used with minor amendments. Gini coefficient is used to measure the transit supply distribution by evolving a Lorenz curve. Transit supply and demand are assessed at the TAZ level. Transportation facility in large, auto oriented cities provides irregular access and mobility aids. However, results show that most of the region's low-income families have poor access to job locations.

Jie Chen, Jianhua Ni et al. (2017) [6]**;** develops a method to evaluate change in disparities of urban spatial accessibility. An internet mapping service is used for more precise travel time information, realistic and door to door modelling method in the multimodal public transportation system to avoid use of complex GIS software for road network modelling. An urban rail mode of travel is added to public transportation in Nanjing, China. Therefore, change in disparities in the city is evaluated. The accessibility to multimodal public transport was accessed by mainly two parameters; the potential accessibility (PA) and weighted average travel time (WATT). The study area is divided into 1091 multilevel grid regarding population density. The study can be used for improvement of public transit system and to determine transport investment needed for Nanjing city.

Jay Shah and Bhargav Adhvaryu (2016) [4]; used London public transport accessibility levels (PTAL) to find the accessibility of Ahmedabad, Gujarat. The study area is about 465 km^2 and it is divided into 675 grid cells to find accessibility. The centroid of each grid cell is considered as point of interest (POI). A GIS software is used to evaluate walking distance. The analysis of PTALs is carried out for morning peak hours 9:30 am to 10:30 am. The reliability factors are assumed as 2.5 and 1 for Ahmedabad Municipal Transport Service (AMTS) and Bus Rapid Transit System (BRTS) respectively. Walking speed is assumed to be 36 km/hr. The secondary data are collected from Ahmedabad Municipal Corporation (AMC) office, Metro-link Express for Gandhinagar-Ahmedabad (MEGA) office and BRTS office. A GIS mapping tool is used for mapping of PTALs using four alternatives; equal break, standard deviation, natural break and quantile break. It is shown that accessibility to the core of Ahmedabad is excellent and becomes poorer as move away from core area as shown in table 1. Accessibility of outskirts of Ahmedabad city are very poorer due to lake of public transport facility. This indicates the radial growth of city.

Tayebeh Saghapour, Sara Moridpour, et al. (2016) [10]; A methodology is developed considering population density to quantify public transport accessibility. For analysis three modes of public transport are considered; public buses, trains and trams. The Melbourne region has 17800 bus stations, 1700 tram stations and 240 train stops. Station and route details were gathered from Victorian Integrated Survey of Travel and Activity dataset. Frequency data are calculated during morning peak hours 7:00 am to 9:00 am. Maximum walking distance from POI to SAP is considered as 400m. Walk time is evaluated by ArcGIS software. A separate ordered logit regression model is developed using VISTA dataset to compare it with existing approach. The public transport accessibility in the CBD of Melbourne is high for all three types of public transport modes. The outer suburban area has lower accessibility due to limited buses.

Yang Sun and Hang Fei Lin (2015) [13]; define accessibility to public transport based on bus travel characteristics. Distinguish between the transit network and the road network to evaluate public transport accessibility. Two definitions are derived; local accessibility and regional accessibility. Local accessibility is the total travelling time or total travelling cost from origin to destination. Isochrone map is used for mapping of local accessibility. Regional accessibility is the number of persons arrive by public transport at all the terminuses within the area in the aximuml acceptable period in terms of the total population and number of stations within the area. The three-dimensional accessibility map is used for presenting regional accessibility. A case study of before improvement and after improvement studies of Wenjiang Hospital and Tongping Hospital by a GIS based software.

Vu Anh TUAN and Duong Thanh SON (2015) [12]; Ho Chi Miinh City (HCMC) is of 2095 km^2 area and 7.4 million population. The public transport accessibility is analysed over space, time and population group. The primary data are collected from interviews and secondary data are from authorized records, newspaper, earlier studies and reports. There are mainly three components of accessibility; Accessibility to stop, accessibility to service and accessibility to vehicle. Researchers analyse different indicators of above three components of accessibility. The accessibility index is assessed on the basis of average level of satisfaction and average level of importance of accessibility indicators. A table is developed that shows the accessibility indices by groups and accessibility situations to be enhanced. The accessibility of HCMC is lower than the average accessibility level.

Parvathy Rajendran, Bindhu B K et al. (2013) [7]; Accessibility to public transport system is evaluated for Thiruvananthapuram, Kerala using public transport accessibility levels. The study area has total area of 2192 km^2 and comprises of 100 wards. The public transport accessibility is assessed using PTAL and public transportation travel. The household sample was accomplished with the aid of a questionnaire form contains trip data and household information and total 560 houses has been surveyed. ArcGIS software is used for mapping of public transport accessibility.

Vimal Gahlot, B.L.Swami, M. Parida et al. (2013)[11]; The availability to public transportation system and accessibility to pedestrian has been evaluated for Jaipur, Rajasthan. Public Transit Coverage Index (PTCI) is used to evaluate availability to public transport network. The numerical indices such as Ideal Stop Accessibility Index (ISAI), Actual Stop Accessibility Index (ASAI) and Stop Coverage Ratio Index (SCRI) has been used to evaluate accessibility to pedestrian. The population of Jaipur city is about 2.3 million. About 210 public transportation buses and 2900 private mini buses are operated which links the urban and suburban areas to core urban area. A GIS software is used for mapping of public transport accessibility of Jaipur city.

Belinda M. Wu and Julian P. Hine (2003) [2]; presents a study of the urban bus system in Northern Ireland and measures the space effect of a proposed system modification on residents inside the urban bus system area. Various theoretical network possibilities are corelate in terms of the influence on residents' structure, vehicle occupancy and religious classes by data gathered in the databases within the GIS. The study illustrates that the theoretical network variations have a inconsistent influence on older citizens as well as other age categories. Households with no vehicle are indicates inferior access to bus facilities in the morning peak and off peak.

III. Conclusion

As per literature review there are several methods to find out accessibility to public transport such as The Local Index of Transit Availability (LITA), The Transit Level-of-Service (TLOS), Transit Service Indicator (TSI), The Transit Capacity and Quality of Service Manual (TCQSM), Transit Accessibility Measure (TAM), The Time-of-Day Tool and Public Transport Accessibility Level (PTAL). The accessibility to public transport can be find out on spatial or temporal basis. Temporal coverage is more important factor than spatial coverage to find accessibility. Primary data such as average walk speed, average walking distance, waiting time, transfer time can be obtained by questionnaire survey and peak-hour route frequencies from secondary data. Mostly preferred method to find public transport accessibility is PTAL. PTAL include both spatial coverage and temporal coverage. PTAL can be obtained by considering average walk speed, average walk time, average walk distances to public transportation stops and peak hour route regularities.

References

[1] Asif Raza and Ming Zhon, "Evaluating Public Transit Equity using the Concept of Accessibility", American Society of Civil Engineers (ASCE), CICTP 2018

[2] Belinda M. Wu and Julian P. Hine, "A PTAL Approach to Measuring Changes in Bus Service Accessibility", Transport Policy 10 (2003) 307–320

[3] Irina Yatskiv, Evelina Budilovich, Vaira Gromule, "Accessibility to Riga Public Transport Services for Transit Passengers", Procedia Engineering 187 (2017) 82 – 88

[4] Jay Shah and Bhargav Adhvaryu, "Public Transport Accessibility Levels for Ahmedabad, India", Journal of Public Transportation, Vol. 19, No. 3, 2016

[5] Jędrzej Gadziński and Michał Beim, "Public Transport Accessibility in Poznań", Real Corp 2010 Proceedings Tagungsband

[6] Jie Chen, Jianhua Ni, Changbai Xi, Siqian Li, Jiechen Wang, "Determining Intra-Urban Spatial Accessibility Disparities in Multimodal Public Transport Networks", Journal of Transport Geography 65 (2017) 123–133

[7] Parvathy Rajendran, Bindhu B K, V S Sanjay Kumar, "Public Transport Accessibility Index for Thiruvananthapuram Urban Area", IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE), Volume 7, Issue 4

[8] Rui Liu, Yun Chen, Jianping Wu, Tingbao Xu, Lei Gao, Xizhi Zhao, "Mapping Spatial Accessibility of Public Transportation Network in an Urban Area – A Case Study of Shanghai Hongqiao Transportation Hub", Transportation Research Part D 59 (2018) 478–495

[9] Su Pe Thu and Kay ThweTun, "Urban Public Transport Accessibility for Markets and Wards: The Case Study of Mandalay City", International Journal of Scientific and Research Publications, Volume 7, Issue 8, August 2017

[10] Tayebeh Saghapour, Sara Moridpour, Russell G. Thompson, "Modeling Access to Public Transport in Urban Areas", Journal of Advanced Transportation, 2016; 50:1785–1801

[11] Vimal Gahlot, B.L.Swami, M. Parida, P. Kalla, "Availability and Accessibility Assessment of Public Transit System in Jaipur City", International Journal of Transportation Engineering, Vol.1/ No.2/ Summer 2013

[12] Vu Anh TUAN and Duong Thanh SON, "Accessibility to Public Transport Systems in Developing Countries – An Empirical Study in Ho Chi Minh City, Vietnam", Journal of the Eastern Asia Society for Transportation Studies, Vol. 11, 2015

[13] Yang Sun and Hang Fei Lin, "GIS-based Analysis of Public Transit Accessibility: Definition and Display", 15th COTA International Conference of Transportation Professionals

[14] Evaluating Accessibility for Transport Planning; http://www.vtpi.org/access.pdf

[15] Measuring Public Transport Accessibility Levels; https://files.datapress.com/london/dataset/public-transport-accessibility-levels/PTAL-methodology.pdf

[16] The Importance of Public Transportation in Your Community; https://www.jjslist.com/blog/importance-of-public-transportation

[17] Why Transportation is Important in India; https://www.iaspaper.net/transportation-essay/