Sufficiency Evaluation of Pune Metro Rail Networks

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Abstract

As India is one of the fastest developing country in world the metro rail network plays an important role in cities transport system so it is now need of future to have an efficient and well effective metro rail network in city. The objective of this research is a preliminary examination of metro rail network extensiveness versus the city's needs, aiming to assist the estimation of the adequacy of a metro network. This study is concentrated on comparing mature metro system in several large European cities with Indian cities based on a selection of indicators relating metro network characteristics i.e. Length and no. of stations, city characteristics eg. Population and density. A methodology exploiting these macroscopic characteristics in a strategic planning context was developed and a combination of related indicators is proposed. This methodology is applied for the estimation of the degree of adequacy of the current Athens, Greece metro network in a relation to city's needs. Findings indicate that the Athens metro network cannot be yet characterized as adequate and specific proposals are made in terms of future network extensions. These proposals served as the initial reference point in a more sophisticated planning process for metro system future development.
Keywords: Athens and Indian Metro network, indicators relating metro network

I. INTRODUCTION

Metro rail system as we know is very important aspect in infrastructural development of the nation. India is a developing country and tending through huge infrastructural growth, after completion of Delhi, Kolkata, Bangalore and Chennai metro, more than 10 metro projects have been planned to be executed till end of 2020. The main objective of this research is a preliminary exploration of metro rail network in relation to the city's Socio-economic needs, which aims to assist a methodology for adequacy assessment of a metro network which is later applied for adequacy assessment of Pune metro rail network. Developing Transport Infrastructure and Services for Population Growth Areas especially in places like India where urban sprawl has risen tremendously is of vital importance. This Project has used comparison of mature metro rail systems across the world based on selection of indicators which relate metro rail network characteristics (example - length, number of stations etc.) to city's important characteristics (example – population, Traffic Nature, Population density etc.)

Scope of this study aims understanding the need of a rapid transit system in rapidly urbanizing Indian cities. It also aims on preliminary exploration of metro rail network with respects to city's needs to present and applicate an methodology to first evaluate the Adequacy of a metro rail network quantitatively and then analyze it specifically. When the analysis is not found to be adequate, definite solutions either make the metro rail network adequate or improve its adequacy are presented. This study will contribute very efficiently in preplanning and prefeasibility of metro rail network so that the metro rail systems will serve to be adequate and sustainable taking in to consideration its present and future needs. Rapid transit in India consists of metro, monorail and light rail systems.

A. Objective:

1) Investigate overall scenario of metro rail adequacy in India. To present, assess and applicate a methodology for obtaining adequacy of metro rail networks for three cities in India i.e. Pune
2) Obtaining the values of Adequacy by Quantitative coefficient's i.e. NLRI (Network Length Related Indicators) & SNRI (Station Number Related Indicators) for all the metro rail networks undertaken.
3) To present a solution to minimize or resolve the problems of Inadequacy of metro rail network in pune city.

II. DATA COLLECTION

Table – 1
Pune city Metro rail characteristics (Sanctioned plan)

City	*Population (Pe)*	*Area (A)*	*Density (D)*	*Length (L)*	*Statin (S)*	*Line (Le)*	*Annual Ridership (Rd)*
Pune	*7.22*	*700*	*8314*	*75.5*	*31*	*4*	*350*

III. METHODOLOGY

Based on the available data presented in Table 1 & 2 calculate the indicators as shown in below:
Population influenced (P; km/person) is the ratio between network length (L) and the reference territory population (Pe; person):

$$P = \frac{L}{Pe} \qquad (1)$$

Network extension (Ne) is the ratio between network length (L) and the network diameter (D):

$$N_e = \frac{L}{D} \qquad (2)$$

Network density (Nd; km/km2) is the ratio between network length (L) and the reference territory surface (Su; km2):

$$N_d = \frac{L}{SU} \qquad (3)$$

Access density (Ad; stations/km2) is the ratio between the number of stations (ST) and the reference territory surface (Su; km2):

$$A_d = \frac{ST}{SU} \qquad (4)$$

Served Surface (S; km2) is the territorial extension up to where network is effective and it is evaluated by multiplying number of stations with average range of influence (R; km2) and subtracting surfaces counted in overlap areas of stations influence:

$$S = ST * (\pi * R2) - [(s1 \cap s2) \cup (s2 \cap s3) \cup \ldots.] \text{ --- (5)}$$

Spatial accessibility or network covering degree (As) is the ratio between the served surface (S; km2) and the reference territory surface (Su; km2):

$$As = \frac{S}{SU} \qquad (6)$$

Traffic density (T; passengers/km) is the ratio of annual (usually) network ridership (RD) and:

$$T = \frac{RD}{L} \qquad (7)$$

IV. RESULT ANALYSIS

It deals with analysis of indicator and analysis of network, indicator coefficient by using the seven formulas mentioned in above methodology.

Table – 3
Pune city Indicators Comparison with other mature metro rail System's indicators

City	*Population influence (P)*	*Network extension (Ne)*	*Network density (Nd)*	*Access density (Ad)*	*Served surface (S)*	*Spatial accessibility (As)*	*Traffic density (T)*
Pune	*0.010*	*5.03*	*0.15*	*0.06*	*130*	*26*	*4.63*
Barcelon	*0.066*	*3.91*	*0.44*	*0.512*	*71.94*	*29.73*	*3.46*
Berlin	*0.039*	*4.04*	*0.16*	*0.191*	*95.88*	*10.75*	*3.23*
Brussels	*0.030*	*2.02*	*0.20*	*0.366*	*13.80*	*8.55*	*3.51*
Buchare	*0.032*	*3.08*	*0.29*	*0.185*	*83.67*	*35.91*	*1.64*
Budapes	*0.019*	*1.83*	*0.06*	*0.076*	*21.37*	*4.07*	*8.48*
London	*0.049*	*5.43*	*0.24*	*0.157*	*487.59*	*28.57*	*2.49*
Madrid	*0.056*	*8.47*	*0.29*	*0.236*	*274.09*	*27.97*	*2.43*
Minsk	*0.017*	*2.53*	*0.10*	*0.079*	*30.03*	*9.83*	*8.71*
Moscow	*0.028*	*4.63*	*0.27*	*0.130*	*477.63*	*44.18*	*8.63*
Munich	*0.036*	*3.65*	*0.16*	*0.158*	*71.45*	*12.1*	*3.57*
Napels	*0.033*	*6.94*	*0.27*	*0.239*	*28.35*	*24.23*	*0.91*
Paris	*0.021*	*8.76*	*0.08*	*0.110*	*118.72*	*4.36*	*6.62*
Rome	*0.014*	*2.04*	*0.05*	*0.056*	*24.87*	*2.92*	*6.97*
Stockhol	*0.038*	*3.75*	*0.28*	*0.265*	*87.70*	*23.25*	*2.81*
Vienna	*0.084*	*4.29*	*0.17*	*0.202*	*45.53*	*10.97*	*6.83*
minimum	*0.010*	*1.83*	*0.05*	*0.056*	*13.80*	*2.92*	*0.91*
Average	*0.038*	*4.69*	*0.24*	*0.20*	*128.84*	*18.49*	*4.69*
Maximum	*0.084*	*8.76*	*0.44*	*0.512*	*487.59*	*44.18*	*8.71*

The comparison of Pune metro rail performance indicators is done by the performance indicators of the other mature metro rail system as minimum, maximum and average (Pune metro excluded) is calculated shown is table above. In the Statistical analysis

values of average performance indicators of 15 mature metro rail networks are considered as datum and the values of Pune metro rail network performance indicators is compared.

A. Analysis of Indicator coefficients

Table – 4
Indicators of Pune Metro rail Network

	Network length –related indicators (NLRI)				*Station number-related indicator (SNRI)*	
	Population influence (P)	*Network extension (Ne)*	*Network density (Nd)*	*Access density (Ad)*	*Spatial accessibility (As)*	*Traffic density (T)*
Pune Indicator	*0.010*	*5.03*	*0.15*	*0.06*	*26.*	*4.63*
Indicator Average	*0.038*	*4.69*	*0.24*	*0.20*	*18.49*	*4.69*
Indicator Maximum	*0.084*	*8.76*	*0.44*	*0.512*	*44.18*	*8.71*
Ratio of Indicator average	*3.8*	*0.93*	*1.6*	*3.33*	*0.71*	*1.01*
Ratio of Indicator maximum	*8.4*	*1.74*	*2.93*	*8.53*	*1.69*	*1.75*
Indicator average	*2.416*				*0.86*	
Indicator maximum	*5.4*				*1.72*	

The study done by using this methodology clears prove that Pune metro rail networks assumed for adequacy assessment of metro rail network is Inadequate as per city's needs, the Indicators for Pune metro rail network indicated the value of NLRI (average) as 2.416 & and SNRI (average) as 0.86 though the value of SNRI is fair enough but the values for NLRI are behind, this may create problems in future for metro rail systems performance.

B. Solutions

Considered various increasing length & number of stations as the following:

Table – 5
Computing NLRI & SNRI by increasing the various lengths & stations

Length	*Stations*	*NLRI*	*SNRI*
75.5	*31*	*2.415*	*0.862*
80	*30*	*2.654*	*0.917*
80	*60*	*1.779*	*0.917*
100	*80*	*1.447*	*1.05*
120	*100*	*1.199*	*1.184*
130	*60*	*1.264*	*1.247*
130	*70*	*1.208*	*1.247*
140	*90*	*1.21*	*1.319*
140	*80*	*1.13*	*1.091*
140	*70*	*1.15*	*1.091*
140	*60*	*1.212*	*1.091*
140	*120*	*1.014*	*1.318*
160	*140*	*0.877*	*1.458*

The above table shows that length 140 km and stations 80 the NLRI 1.13 and SNRI 1.091 are fair enough. Hence it is more adequate than sanctioned plan.

C. Final Result Obtained:

1) Sanctioned Plan: For 75.5 km length and 31 stations

Pune	*NLRI*	*SNRI*
Indicator Avg.	*2.416*	*0.862*
Indicator Max.	*5.402*	*1.725*

2) Decided Plan: For 140 km length and 80 stations

Pune	*NLRI*	*SNRI*
Indicator Avg.	*1.113*	*1.091*
Indicator Max.	*2.584*	*2.592*

V. CONCLUSION

The main objective of this research is preliminary examinations of metro rail network with respect to city's needs, which will help to assist the estimation of the adequacy assessment of a metro network. This study concentrated on comparing mature metro systems in several large cities across the world (mainly Europe) based on a selection of indicators relating metro network characteristics to a city's characteristics. The success of a metro system, as of any transit system, is to respond at least adequately to a city's transportation needs. Consequently, the methodology presented in this study can be used as the initial step and can be applied in conjunction with full-scale transportation planning studies.

The results of the methodology were initially evaluated through a more sophisticated planning process for the Indian metro system future development in combination with land use and employment density forecasts as well as mobility trends of the city. This initial evaluation showed that the methodology presented can provide results to serve as a reference point for a more sophisticated planning process. Aiming in this way at a gradual, efficient, and according to City's needs can be very helpful in the Indian metro system development.

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