A PRESENTATION FOR TIPCE2019

Planning and Optimising Services of a Public Transportation System

Presented By

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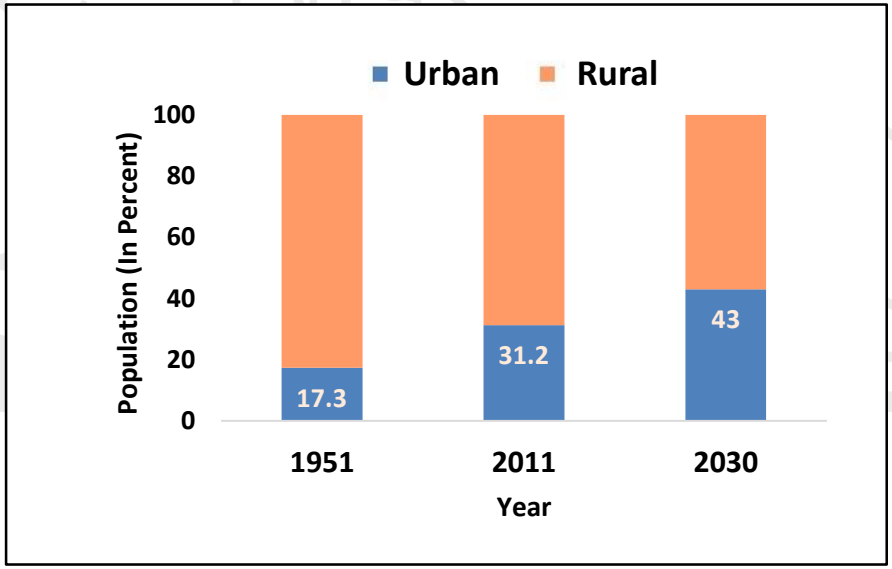
Introduction

Urban Cities:

- Engines of growth.
- Nearly 65% of India's GDP contribution & will reach 70% by 2030 *(MoHUA Annual Report, 2016-17).*
- 31.1% of country population and expected to be 43% by 2030 *(Census of India, 2011).*

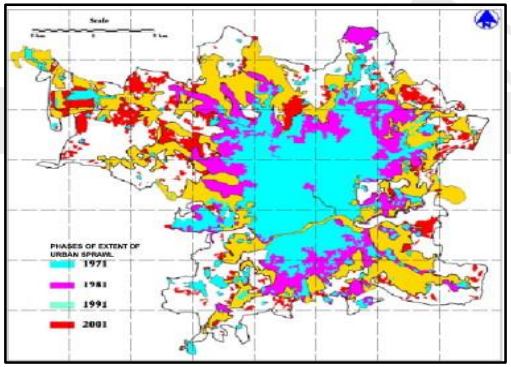


Source: Census of India, 2011

Introduction...Cont'd

Urban Transport:

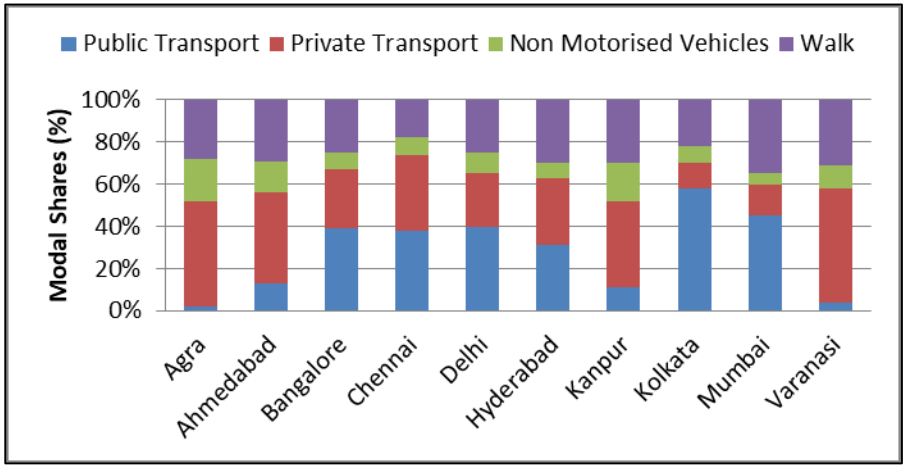
- Objective: for prosperous lives, health and jobs opportunities by preserving environment.
- Challenges:
  - Shooting Population
  - Urban Sprawl
  - Rise in Travel Demand
  - Disproportional Mode Choices
  - Growing Vehicular Population
  - Congestion
  - Emissions
  - Increased Travel Time
  - Delay



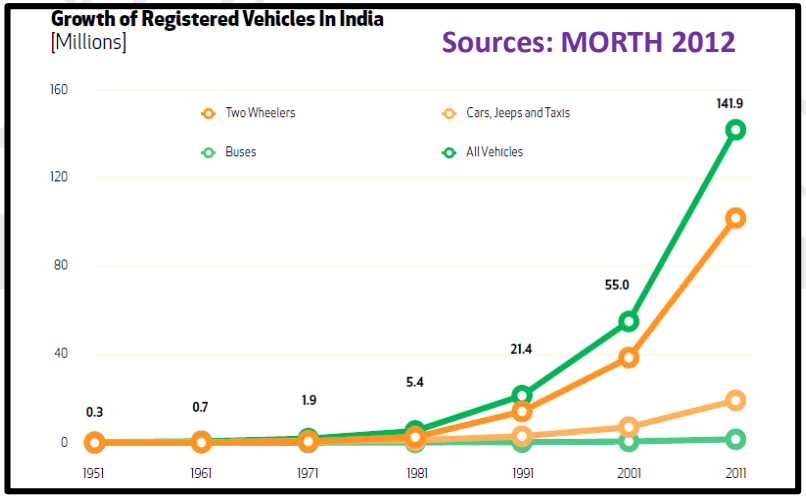
Public Transportation Scenario

City Category	City Population (Range in Millions)	WSA, 2007 (Percent)	RITES, 1994 (Percent)
1	<0.5	0 – 15.6	14.9 - 22.7
2	0.5 – 1	0 – 22.5	22.7 – 29.1
3	1.09 – 2	0 - 50.8	28.1 – 35.6
4	2 – 4	0.2 - 22.2	35.6 -45.8
5	4 – 8	11.2 - 32.1	45.8 – 59.7
6	Above 8	35.2 – 54.0	59.7 – 78.7

Public Transport Share Comparison for different cities
(India Transport Report: Moving India to 2032-Vol. 3, NTDPC 2014)



Model share of vehicles in major cities of India
(International Forum of Contemporary Architecture, 2009)



Public Transport Planning

- Public Transport: viable option for Sustainable Transportation

Stages of Planning *(Cedar and Wilson 1986)*

1. Route Network Design
2. Frequency Setting
3. Schedule Development
4. Fleet Assignment
5. Driver Assignment

Three C's *(Vuchic, 2005)*

- **C**ontinuing
- **C**ooperative
- **C**omprehensive

Integrated Approach

- Improve Transport Efficiency
- Lower Costs To Deliver Economic Growth Goals
- Cause Low Social Impacts
- Efficiently Utilise Public Funds

- Institutional
- Transport Physical
- Network Resources

Public Transport Planning...Cont'd

- **Accessibility Versus Mobility**

  Case Example: Comprehensive Mobility Plan *(MoUD 2014)*

  – improvement and promotion of public transport and

  – guidelines regarding mobility of people to combat urban transport problems are proposed

- **Service:** Design to accommodate level of service required by consumers.

- **Concentrate:** Travel Behaviours, Needs & Expectations.

Performance & User's Expectations

- **Public Transport Performance:** Boost if user's required attributes meet with the provided service. *(STIMULAS, 1999; Prioni and Hensher, 2000)*

- **Service Quality Attributes** *(Das and Pandit, 2012).*
  - ❑ Safety
  - ❑ Comfort
  - ❑ Reliability
  - ❑ Frequency
  - ❑ Cost
  - ❑ Lack of Information
  - ❑ Travel Time
  - ❑ Waiting Time
  - ❑ No of Transfers etc.

  Influences on modal choices

- **Travel behaviour:** Not directly influenced by the service level but is influenced by the psychological factors. *(Fujii and Kitamura, 2003).*

Modelling User's Desire & Expectations

- **Complexities Arises**: Perception and quantifiable service attributes varies among group of users. *(Das and Pandit, 2013)*

➢ Perception based measures

➢ Weighted Perception Measures:

Statistical Techniques: Fails to predict the future service quality

- ✓ Structural Equation Modelling
- ✓ Quadrant Analysis
- ✓ Factor Analysis
- ✓ Ordered Logit/Probit Models
- ✓ Impact Score and
- ✓ Analytical Hierarchy Process

➢ Service Quality Index: Realistic results not possible *(Hensher and Prioni, 2002)*

➢ LOS Tool: Outcome of user's perception towards Quality of Service Parameters (QOS).

Modelling User's Desire & Expectations…Cont'd

- **LOS Methods:** Qualitative and Quantitative Measures.
  - ✓ quantitative methods limits the expression of the users confining to the research prospects, whereas, qualitative methods have depth of information from few individuals.

- Case Examples:
  - ✓ In India, MoUD, GoI (2009), considers six parameters to define LOS in Indian context based on expert judgement contrary to users' perception.
  - ✓ TCQSM presents six LOS based on quantitative parameters identified by expert opinion.

- The need to develop LOS ranges based on users' perception towards QOS is identified as a future area for research.

Service Optimization

Fall in Ride Share

- Fixed Origin, Destination and Intermediate Stops
- Socioeconomic Growth
- Need for Personalized Mobility
- Increase in Private Vehicle & Urban Population
- Urban Sprawl

Dynamic Travel Demand Scenario

- Change In City Land Use And Trip Activities

Existing Transit Service

"Inherent Issues"

Service Optimization… Cont'd

Short-Term Measures

- ✓ Quick, Temporary and Low cost
- ✓ Results in immediate effect.
- ✓ Transport System Management Measures

Long-Term Measures

- ✓ Optimisation of network routes, service, scheduling etc.
- ✓ Yields long and improvised services

- **Service Optimisation**: Interpreted in terms of users' and operator's costs either taken together or on individual bases with defined objective function and constraints.

- Conflicts each other and optimisation between those yields decrease in transport cost with increase in quality of service.

Service Optimization…Cont'd

- Practical Guidelines & Ad-hoc Procedures

- Analytical Optimisation Models
  - ✓ Considers design parameters such as route spacing, route length, stop spacing, frequency etc.
  - ✓ Computation process is complex and time consuming due to:
    - ✓ Non-linearity, multiple linear numerical problems
    - ✓ Involvement of no. of variables and constraints in the objective functions *(Newell 1979, Baaj and Maahmasaani 1991 & 1995).*

- Meta Heuristics Algorithmic approaches *(Fan and Machemehl 2006).*

- Modern Nature Inspired Optimisation Techniques. *(Nikolic and Teodorovic, 2013; Arbex and Cunha, 2015)*

Ridership Estimation

Impact on Ridership: Influenced by changes in the network or services at passenger level

- Four Step Modelling
  - ✓ Accuracy and relevance of approaches studied on regional scale
  - ✓ Limitation: Does not focus for transit ridership.
- Direct Ridership Model (DRM)
  - ✓ Based on Multiple Regression
  - ✓ Ridership = f (station environment, transit service features) *(Cervero et al. 2010)*.
  - ✓ Few focussed on
    - Spatial variations by using Geographically Weighted Regression (GWR),
    - Pedestrians' walking distance altogether with DRM,
    - Ordinary Least Square (OLS) regression by considering Hierarchical Linear Model (HLM) for same stops in common route, etc.*(Gutierrez, 2011)*
  - ✓ Fails to predict the ridership due to spatial variations in route and station spacing, geographic conditions, station buffer zones etc. *(Chow et al. 2006).*

Ridership Estimation…Cont'd

- Fuzzy Logic Interface
  - ✓ Predicting ridership on the basis of index for transit service quality, accessibility, bus stop and demographic conditions *(Kikuji and Miljkovic, 2001).*

- Back Propagation Neural Network (BPNN)
  - ✓ Population band width was used where ridership varies nonlinearly with the explanatory variables *(Jungfang Li et al., 2016).*

Conclusions

- The Public Transport planning and its services is identified as holistic and comprehensive study promoting accessibility rather than mobility in its goals.
- The passenger travel behaviour is not directly related to the quality of service but indirectly related to the perception about the service and psychological factors of user.
- The current practices of measuring quality of service fails to incorporate users and practitioners opinion altogether.
- The Transit System plan and its services should be an continuous re-evaluation and upgradation process based on user desired level of service and travel behaviour patterns for optimal usage of the systems.
- The optimum transit services and designs obtained from modern nature inspired techniques and meta heuristics optimisation methods show efficient result than analytical and heuristics optimisation methods.
- There is an need of ridership development model which can consider spatial variations in route and station spacing, geographic conditions, station buffer zones etc.

References

1. Baaj, M. H., and Mahmassani, H. S. (1991). “An AI-based approach for transit route system planning and design.” J. Adv. Transp., 25(2), 187–210.
2. Baaj, M. H., and Mahmassani, H. S. (1995). “A hybrid route generation heuristic algorithm for the design of transit networks.” Transp. Res.- C, 3(1), 31–50.
3. Ceder, A., and Wilson, N. H. M. (1986). “Bus network design.” Transp. Res. - B, 20(4), 331–344.
4. Census of India, 2011. Retrieved in April 2018.
5. Chow, L.-F., Zhao, F., Liu, X., Li, M.-T., Ubaka, I., 2006. “Transit ridership model based on geographically weighted regression”. Transport. Res. Rec. 1972, 105–114.
6. Das, S., & Pandit, D. (2012). “Methodology to identify the gaps in the level of service provided for urban bus transit: Case study Kolkata”. SPANDREL, 4 (Spring), 59–71.
7. Fan, W., and Machemehl, R. (2006). “Using a simulated annealing algorithm to solve the transit route network design problem.” J. Transp. Eng., 132(2), 122–132.
8. J. Gutierrez, O.-D. Cardozo, and J. C. Garcıa-Palomares, (2011) “Transit ridership forecasting at station level: an approach based on distance-decay weighted regression,” Journal of Transport Geography, 19 (6), pp. 1081–1092.
9. Kikuchi, S., and D. Miljkovic. (2001). “Use of Fuzzy Inference for Modeling Prediction of Transit Ridership at Individual Stops”. Transp Res. Record 1774, pp. 25–35.
10. L. Junfang, Y. Minfeng, and F. Qian, (2016). “Forecasting Method for Urban Rail Transit Ridership at Station Level Using Back Propagation Neural Network”, Discrete Dynamics in Nature and Society Volume 2016, Hindawi Publishing Corporation (9527584), 9 pages.

References

11. Ministry of Housing and Urban Affairs Annual Report 2016-17, Government of India.
12. National Urban Transport Policy (2014). Published by Ministry of Urban Development, Government of India.
13. Newell, G. F. (1979). “Some issues relating to the optimal design of bus routes.” Transp. Sci., 13(1), 20–35.
14. Nikolic´, M., Teodorovic´, D., (2013). “Transit network design by bee colony optimization”. Expert Systems with Applications 40, 5945–5955.
15. Preparing a Comprehensive Mobility Plan (CMP)—A Toolkit. (2014). Ministry of Urban Development, Government of India.
16. Robert Cervero, Jin Murakami, and Mark Miller, (2010). “Direct Ridership Model of Bus Rapid Transit in Los Angeles County, California”, Transp Res Record 2145, pp. 1–7.
17. Tom, V. M., and Mohan, S. (2003). “Transit route network design using frequency coded genetic algorithm.” J. Transp. Eng., 129(2), 186–195.
18. Verma, A. and Ramanayya, T. V. (2015), “Public Transport Planning and Management in Developing Countries”, ISBN-13: 978-1-4665-8160-9; 1st Edition, CRC Press Taylor & Francis Group
19. Vuchic, V. “Urban Transit Operations, Planning, and Economics”, Wiley, New York (2007).

Thanks !