Fuzzy AHP Approach to Evaluating Bus Rapid Transit Systems: A Review of Methodologies and Applications

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ABSTRACT

Urban transportation is one of the principal and significant elements of urban system that supplies the accessibility of citizens to different requirements. Growth of population in large cities and transportation growth have been caused many environmental problems. So, public transportation specifically Bus Rapid Transit (BRT) is suitable solution for solving these problems. Public Transport System in most Indian cities is rapidly deteriorating because of the increasing travel demand and inefficient transportation system. Due to inefficient public transport system in India various problems like Accidents, Environmental degradation, Congestion, and Overcrowding have increased. Some studies conducted on BRTS mainly concentrated on particular corridors which raise challenge to safety of traffic.

I. INTRODUCTION

Transportation is the backbone to the development of country. It helps in functioning of urban areas efficiently by providing access and mobility. Passenger has an overriding influence on the functioning of the city. With growth, the mobility needs to be increased. The mobility can be increased in two ways, by encouraging private transport services like auto-rickshaw, private buses, and taxis or by public transport systems. Instead of private transport system we can choose public transport system because urban sprawl and poor land use planning contribute substantially to traffic congestion, air pollution, and greenhouse gas emissions. And public transport helps in reduction of sprawl by attracting development around transit stations, and this development also supports public transport by encouraging ridership. Hence transportation and community planning officials throughout the world examined improved public transportation in addressing their urban mobility issues. Public transport system is a key component of development of any country. Modal share of public transport is declining in most of cities due to various problems related with public transport such as tremendous increase in number of accidents, environmental degradation, Congestion; Overcrowding due to inadequate system, Frequency of service and schedule is not strictly adhered.

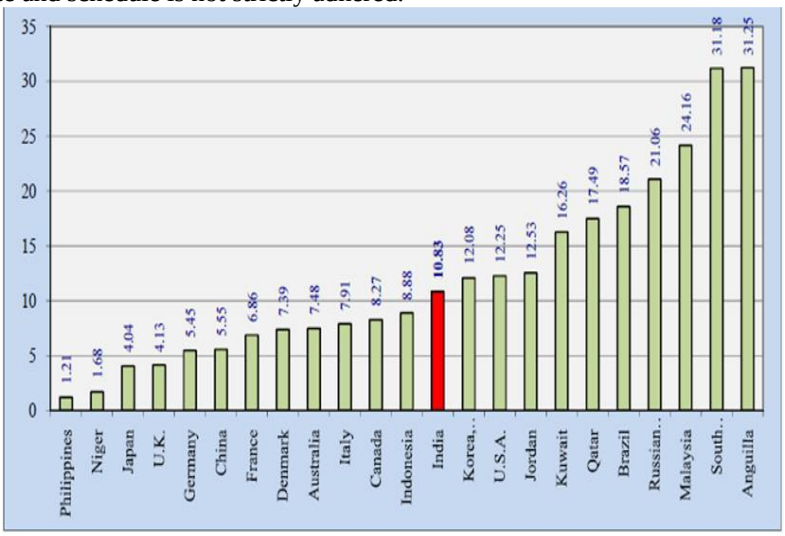

Figure 1.1: Country-wise Number of Persons Killed per 100,000 Populations
(Source: MORT&H, Road Accidents in India, 2013)

The problem of pollution, safety and inefficiency have reached at an alarming level in most of the major cities in India due to unabated growth of its population both of people and motor vehicles. Figure 1.1: shows Country-wise Number of Persons Killed per 100,000 populations by accidents. In comparison to many developed and developing countries the number of road accident deaths per lakh of population at 10.83 in India was much higher compared to Philippines(1.21), Niger(1.68), Japan(4.04), Germany(5.45), China(5.55),France(6.86), Australia(7.48), Italy(7.91) and Canada(8.27) in 2009 as presented in Figure 1.1.

Therefore, India has most important issue to consider a sustainable ecology friendly and economical transport mode. It is believed that ecology friendly transportation should be a high-capacity public mode providing advance technology features, and luxurious yet comfortable facilities while having lower emission, moving faster and safer, and most importantly, being attractive to commuters. Moreover, it should be a financially affordable system to developing countries. The Bus Rapid Transit System (BRTS) is one such mode intended to fulfil these criteria.

Bus rapid transit system (BRTS)

BRTS is a public mode of transportation providing high capacity and consuming cleaner fuels. It also has any comfortable and luxurious facilities with high technology functions for faster and safer travel, including exclusive busway, convenient stations, comfortable articulated buses, and Intelligent Transportation Systems (ITS) such as signal priority system, automatic fare system, Global Positioning System (GPS), bus arrival broadcast information, bus guidance, etc. Outstandingly, its investment cost is very effective, compared with other transit systems .India currently has a number of operational BRT systems in various cities like Ahmadabad, Pune, Delhi, Mumbai, Indore, Bhopal, Jaipur and Rajkot. Table 1.1 is showing BRTS implementation in some Indian cities.

Table 1.1: BRT Projects implemented in India

Cities	Length (KM)	System	Segregation	Bus Stop Location	Ticketing System
Ahmadabad	106	Closed	Yes	Middle	Off Board
Rajkot	40	Closed	Yes	Middle	Off Board
Surat	29.90	Closed	Yes	Middle	Off Board
Bhopal	26	Open	Yes	Middle	Off Board
Indore	12.045	Partially Open	Yes	Middle	Off Board
Pune	112	Open	Partial	Middle	Off Board
Vijaywada	15.50	Open	Yes	Middle	Off Board
Vizag	42.80	Closed	Yes	Middle	Off Board

(Source: Ministry of Urban Development, 2013)

Need for bus rapid transit system (BRTS)

There is a great need to ensure that the public transportation systems are safe, efficient, affordable and effective. Bus Rapid Transit System (BRTS) is one such solution. Bus Rapid Transit (BRT) has been defined by Levinson et al. (2003) as "Implementation of a flexible, high performance rapid transit mode that makes a physical, operating and system elements into a permanently integrated system with a quality image and unique". Bus Rapid Transit System (BRTS) has gained popularity around the world, since it is claimed that it provides fast, green, safe and efficient service. The cost of a BRTS project can be about one-third the cost of a Rail Transit project. BRTS can provide quality performance with sufficient transport capacity. The efficiency of the system and high capacity of the passengers depends on the system as a whole and not necessarily on the size of buses, though when necessary articulated buses could be used with ease. BRTS is designed and developed to tackle all the drawbacks of the existing bus systems in an economical and efficient manner. It is a low-cost option for providing cities with a quality transit option.

Performance evaluation of BRTS

Performance evaluation may be defined 'determining how well policies, programs and projects perform with regard to their intended goal and objectives'. Satisfaction of user is an important part of performance evaluation because passenger satisfaction is directly related to the expectations of service quality and the actual level of service. Therefore, measuring the satisfaction and the importance of measures and combining them is essential for monitoring the performance of transportation systems. Performance indicators are specific measurable outcomes used to evaluate progress toward established goal and objectives. Gandhi et. al(2009) reported that more than 100 indicators are involved in BRTS design. Approximately one-third of parameters are related to site

conditions and hence fixed. The remaining two-thirds of parameters are variable and depend on design. The performance of any system depends on a set of factors, thus it becomes necessary to study the important parameters in detail and arrive to a set of indicators that are of prime importance.

AHP and fuzzy AHP

The Analytic Hierarchy Process (AHP) is a multi-criteria decision making approach in which factors are arranged in hierarchic structure. With AHP method, a complicated system is converted to a hierarchical system of elements. In each hierarchical level, pair-wise comparisons of the elements are made by using a nominal scale. These comparisons constitute a comparison matrix. To find the weight of each element, or the score of each alternative, the Eigen vector of this matrix is calculated. At the end, the consistency of the pair-wise comparisons is calculated by using a consistency ratio. If it is below a predefined level, the comparisons are either revised by the decision-maker or excluded from the calculations. AHP method uses hierarchical structures to represent a problem and then develop priorities for alternatives based on the judgment of the users. The important consequences of the choice outcome may confer a level of uncertainty on the decision maker, in the form of doubt. This is one reason for the utilisation of Fuzzy AHP, with its allowance for imprecision in the judgements made.

Fuzzy AHP is a systematic decision making method which includes both qualitative and quantitative techniques. Inconsistency in judgment in survey means that in many practical cases the human preference model is uncertain and decision-makers might be reluctant or unable to assign exact numerical values to the comparison judgements. For instance, when evaluating different indicators, the decision-makers are usually unsure in their level of preference due to incomplete and uncertain information about possible indicators provided for the evaluation. It is very difficult for the decision-maker to exact preferences and to provide exact pair wise comparison judgements. Fuzzy AHP is used to rectify small inconsistency in survey.

Public transport

Public transport means a system of vehicles such as buses and trains which operate at regular times on fixed routes, used by the public. Alternatively, public transport is adequate for mass mobility; it makes better use of urban space, reduces the reliance on more polluting modes of transport, and is likely to be affordable means of transport of most residents in cities. A flexible, safe, comfortable, economic, easily available and reliable bus service may encourage shift from private vehicles to public transport. Since travel demand vary over time and space, public transport systems often have underutilized capacity at non peak hours and high load factor in peak hours. There is an ever increasing preference towards use of personnel vehicles for commuting due to absence of a robust public transport service which in turn leading to the problems of road congestion, pollution, lack of safety leading to increasing number of road fatalities.

II. LITERATURE REVIEW

According to Wright (2004) the problem related to public transportation is congestion, road accidents and increased consumption of petroleum fuels.

Congestion

Congestion which is an outcome of two factors. First is growth in number of vehicles on road and second is a limitation to expansion of road space growth in number of vehicles. The increased travel demand has resulted in rapid growth in the number of motor vehicles in the cities. In the six major metropolises of India, growth in motor vehicles has outpaced Population growth. On an average, while the population in India's six major metropolises increased 1.89 times during 1981 to 2001, the number of registered vehicles went up 7.75 times more during the same period as shown in Figure 2.1. Thus the growth of motor vehicles was almost four times faster than the growth of population. Cities without good mass transit systems, like Delhi, Chennai, Hyderabad and Bangalore, showed a higher growth rate in vehicular population as compared to those with mass transit systems.

Growth in the number of motor vehicles cannot be matched by a corresponding expansion in road space, as there are limits to how much road space can be provided within a city. Resource constraints have come in the way of adequate investments in increasing road capacity and even in undertaking timely repair. Inefficient systems of construction coupled with poor maintenance have resulted in poor road infrastructure. The situation is further exacerbated by unimaginative design of roads that do not allow segregation of vehicles travelling at vastly different speeds. Mobility is thus restricted to the speed of the slowest vehicle. Even at low proportions (10 per cent of the traffic mix), non-motorized vehicles reduce the operating speed of motor vehicles significantly (Moazzem and McDonald 1998). Smaller towns with narrow and poorly maintained roads face this problem more acutely.

Road Accidents

The number of road accidents has increased, from about 161,000 in 1981 to over 400,000 in 2001. The number of fatalities has gone up from 28,400 to almost 81,000 during this period affecting the poor most adversely. About 57 per cent of the persons killed in road accidents in Delhi during this period were pedestrians and cyclists. Another 21 per cent were scooter/motorcycle users (Figure 2.2)

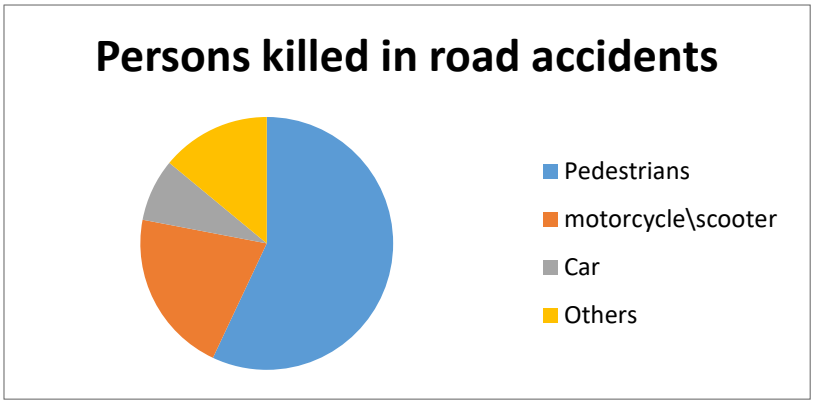

Fig. 2.2 Person kill in road accidents

(Source: Agarwal O.P.(2011)

Increased Consumption of Petroleum Fuels

The emerging pattern of urban mobility has also had its impact on the consumption of petroleum products, which has gone up substantially (Figure 2.3). The net foreign exchange outflow on importing crude oil and petroleum products increased from about Rs 5250 crore in 1980–1 to Rs 1, 12,000 crore in 2004–5 (GOI 2005). The rising trend in the consumption of petroleum products has a bearing on India's energy security, especially because India depends on imports for a large share of its crude oil requirements.

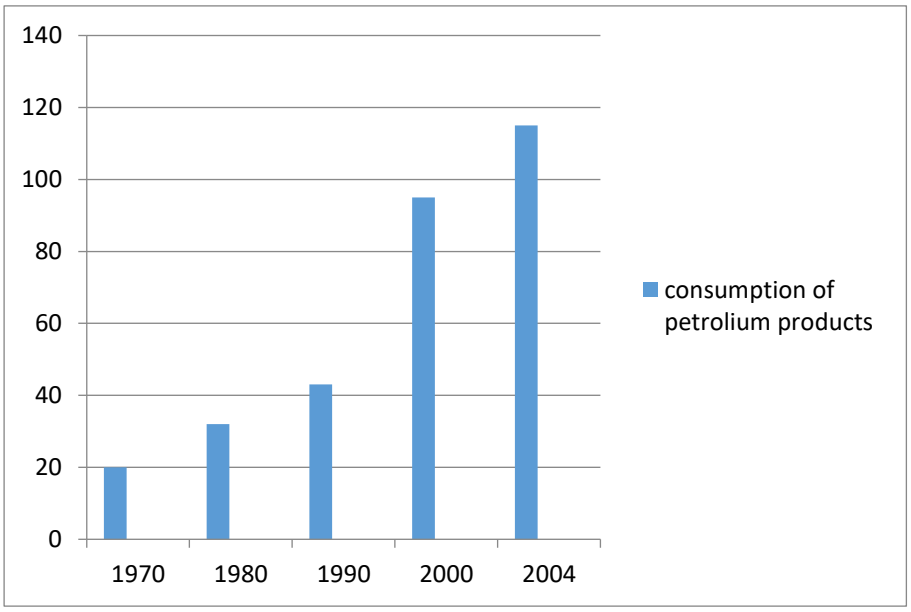

Fig 2.3: Consumption of Petroleum Product (Source : Agarwal O.P.; 2011)

BRTS

"Rapid transit is not a transport mode as such, but, it is means of mass transportation offering a faster service than the alternatives which are available, typically with average operating speeds of 50 kmph or more; this generally requires exclusive rights of way". Rapid transit services are commonly provided by light rail, but certain heavy rail systems also fall into this category. Guiding bus services which operate on dedicated rights-of-way and which are therefore faster than those sharing road spaces with other traffic. BRT is a flexible, high performance rapid transit mode that combines a variety of physical, operating and system elements into a permanently integrated system with a quality image and unique identity". (Diaz et al; 2004)

"Bus Rapid Transit System (BRTS) is an innovative, high capacity, lower cost public transport solution that can significantly improve urban mobility" (Agarwal P.K et al; 2010)

"Bus Rapid Transit gives communities the best bang for their buck when it comes to investing in transit. This new system will better connect workers to jobs, shoppers to stores and Oregon to the rapidly growing economy."(Norman Y. Min et al; 2006).

BRTS benefits

Agarwal P.K et al., 2010 overviews bus rapid transit system and say that Bus Rapid Transit System (BRTS) is a pioneering, high capacity, lower cost public transport solution that can significantly improve urban mobility. BRTS is generally less costly to build than rail transit. BRTS can be the most cost-effective means of serving a wide variety of urban and suburban environments. BRTS can provide quality performance with enough transport capacity. BRTS system can utilize a wide range of vehicles, from standard buses to specialized vehicles. ITS): A wide variety of ITS technologies can be integrated into BRT System to improve BRT System performances in terms of travel times, reliability, convenience, operational efficiency, safety and security designing a service plan that meets the needs of the population and employment centres in the area and matches the demand for service is a key step in defining a BRT system. Saving in travel time on the exclusive travel ways the

person minutes saved is more than the person minutes lost by people in automobiles, which means significant saving in travel time. By creating segregated bicycle lanes and redesigning intersections, conflicts between motorized traffic and bicyclists can be reduced leading to a sharp decrease in the number of accidents and fatalities for bicyclists and motorized two-wheelers. Exclusive travel ways result in to increased capacity.

Problem related to BRTS

According to Jain et. al., 2012 problems related public transportation are as follows:

1) Design Issues

BRT System allocates space on an equitable basis for all types of vehicles like motorized vehicles, non-motorized vehicles and buses. However, the introduction of the Transit system led to significant traffic problems, i.e. mainly congestion and lining up of vehicles at the junctions in motorized vehicle lane. It has been observed that in the peak hours there are some delays and congestion

2) Traffic Signals

Current traffic signals fail to discharge the traffic at peak hour, as traffic flow is not stable and creates a long queue of cars in motorized vehicle lane as well as the bus Lane. Currently, static traffic signal system is installed at BRT corridor, and on many times it is restored to manual operations of the signals. However, the manual control of signals is incompatible with efficient operations. Manual control tends to operate one phase at a time which is inefficient. Manual and automatic systems have conflicting/dangerous signal phases, thus, switching system from automatic to manual and vice-versa can be dangerous.

3) Environmental Considerations

The present system fails to be environment friendly. When BRTS was introduced, residents were promised that it would reduce pollution. But now, they are using the high polluting diesel buses for the project, hence they cause pollution and they are not environment friendly. In addition, trees were cut for BRTS corridor. As per the HC guidelines, the agencies have to plant five trees of at least five feet height for every one tree cut and they have to take care of the plants for five years. But nothing is being done till now.

Performance evaluation of BRTS

Chaurasia ; 2014 studied the salient features and properties of BRT system with the help of various operational BRT and system is funded by central government under JNNURM scheme. Constructed by Bhopal Municipal Corporation (BMC) funds allocated are around 237 crores. Bhopal BRT (My Bus) operating agency is Bhopal City Link Limited (BCLL)., Bhopal BRT system is passing through the main city and market areas supported by Trunk, Standard, Complimentary and Intermediate Para Transit (IPT) routes. The existing 'Mini Buses' & 'Magic' is going to use the complementary and IPT routes to provide transport services for passengers from inner residential area to main trunk and standard routes i.e. BRT routes. The BRT route is 24 K.M. long with 82 bus stops connects the various parts of city to sub-urban.

'Misrod' area at Hoshangabad Road to 'Bairagarh' area at other end. One may identify Bhopal BRT system as 'MyBus'. Currently around 45,000 passengers using BRT daily, by the next year users would be increase and the number of users will reach 1,00,000. Therefore, BRT operating agency BCLL is proposes to procure 'Articulated Buses' (two or three buses combined together in length) to overcome the future demands of buses.

At last, he is presenting an observational study of Bhopal BRT system to analyse the actual condition and lacunas of BRTS. For this purpose he performed a survey on BRTS user towards BRTS and results shows that 100 % positive respond towards BRTS and 73% user travel 5-10 KM.

Jaiswal A. et al; 2012 studies the impact of BRT System on Ahmadabad's transport sector and the changes that can be brought about by introduction of BRT System in other cities. They found that BRTS Ahmadabad has improved access for local riders and advanced public transportation systems while reducing the environmental impacts of transportation. They also discuss the characteristics of BRT like provision of dedicated lanes, frequency of operation. BRTS have more flexibility compared to light rail and BRT routes can be adjusted and rerouted over time. The case study is Janmarg BRTS, Ahmadabad. As Ahmadabad has a well-developed ring radial structure, no single mode is adequate to meet the mobility needs. Both the phases of BRT are so designed, that they don't overlap the areas in which Ahmadabad Municipal Transit Service is provided. Janmarg has also proper feeder systems which feed people for the running of BRT system. In Ahmadabad Pilot project of 5 corridors on phase-II is selected for case study. They identified parameters like Traffic impacts, Social impacts and Environmental impacts. Traffic impact parameters analyzed are, Traffic composition, Peak hour traffic flow and Change in average speed in the corridor. In Social Impacts the parameters are Impact on road safety and Accidents. In Environmental Impacts the parameters are Impact on air quality in that area and Change in SPM, CO, NO levels. Traffic flow study is carried out to understand the efficiency level ofthe traffic system and to correlate with the proposed capacity. The traffic experiences a free flow which causes an increase in the average speed along the corridor. The user rating analysis shows that, the citizen who use the system are very much satisfied with the system. Due to BRT being implemented congestion decreased on the BRT corridor as private vehicles are shifting towards the public transport mode and there is a slight decrease in composition of the pollutants along all corridors.

Hook et. al; 2012 A evaluation provides very high rating for barrier controlled off-board ticketing at BRTS station because it minimize fare evaluation which help in data collection and multiple routes are accommodated using the same infrastructure while the scorecard identifies positive impact on bus operations and system management, the overall negative impact due to delays and queues at turnstile for passengers is not recognised or evaluated. One reason for this could be that operator specific data is easy to collect. Thus, many such standard are based on observable system characteristics and not any quantifiable data. User indicator plays a prominent role in determining whether a system is used and thus deserve careful attention while planning, designing or evaluation a system.

Gandhi et.al; 2014 on his study "Comparative Evaluation of Alternate Bus Rapid Transit System (BRTS) Planning, Operation and Design Options "examined alternate planning, operational and design options for Bus Rapid Transit Systems. In this study quantified performance results for different indicators for various planning and design configurations are generated using a spreadsheet tool. Sixteen theoretical configurations, two standard designs in varying contexts and two currently operational design variations are compared. His results show that bus operational speeds in open systems are approximately 25% less than those in closed systems. However, high operational speeds do not help offset passenger transfer delays for short trips. Open systems provide higher passenger speeds than closed bus operations for trip length less than 10km. Restricting peak bus speed to less than 40km/h for safety considerations does not hamper passenger or operational performance.

AHP

Thomas et al., 2008 States that basic concept of Analytical Hierarchical Process (AHP) are described. Analytical Hierarchical Process (AHP) has been developed by T.Saaty. The Analytic Hierarchy Process (AHP) is one of the best known and most widely used techniques to determine the relative importance of various components and subcomponents to achieve a goal. It allows users to assess the relative weight of multiple criteria or multiple options against given criteria in an intuitive manner.TheAnalytic Hierarchy Process (AHP) is a multi-criteria decision-making approach and was introduced by Saaty (1977 and 1994). The AHP has attracted the interest of many researchers mainly due to the nice mathematical properties of the method and the fact that the required input data are rather easy to obtain. The AHP is a decision support tool which can be used to solve complex decision problems. It uses a multi-level hierarchical structure of objectives, criteria, subcriteriaand alternatives. The pertinent data are derived by using a set of pairwise comparisons. These comparisons are used to obtain the weights of importance of the decision criteria, and the relative performance measures of the alternatives in terms of each individual decision criterion. If the comparisons are not perfectly consistent, then it provides a mechanism for improving consistency.

AHP method of pair wise comparison involves the following steps:

- Step-I Decompose the problem in to a hierarchical frame
- Step-II Collect the input data by pair-wise comparison of various component
- Step-III Estimate the relative importance of the components with respect to components at one level higher (referred as local weights) using the pair wise comparison and check the consistency.
- Step-IV Aggregate the local weight of various levels obtained from step-III to determine the global weight with respect to first level.

Senayoguztimur, 2010 states that Basically AHP is a method of breaking down a complex, unstructured situation into its components parts; arranging these parts, or variables, into a hierarchic order; synthesize the judgments to determine which variables have the highest priority and should be acted upon to influence the outcome of the situation. It uses a hierarchical structure to abstract, decompose, Organize and control the complexity of decision involving many attributes, and it uses informed judgment or expert opinion to measure the relative value or contribution of these attributes and synthesize a solution. AHP is one of the most convenient methodologies in order to evaluate transportation issues. First of all, any selection/priority/decision issue consists of various criteria. Frequently these criteria have sub-criteria as well. In this case criteria have to be taken into consideration are quite much. Either objective or subjective considerations or either quantitative or qualitative information might evaluate with AHP technique. Any level of details about the main focus can be listed or structured in this method. By this way the overview of the main focus or theproblem can be represented very easily. Advantages and disadvantages of AHP are presented in table 2.1 below.

Advantage of AHP	Disadvantage of AHP
AHP can take into consideration the relative priorities of factors or alternatives and represents the best alternative	There is not always a solution to the linear equations.
AHP provides a simple and very flexible model for a given problem.	The computational requirement is tremendous even for a small problem.
AHP provides easy applicable decision making methodologies that assist the decision maker to precisely decide the judgments.	AHP allows only triangular fuzzy numbers to be used.
AHP relies on the judgments if experts from different backgrounds; so the main focus or the problem can be evaluated easily from different aspects	AHP has a subjective nature of the modelling process is a constraint of AHP. That means that methodology cannot guarantee the decisions as definitely true.
AHP has a very wide range of usage like; planning, effectiveness, benefit and risk analysis, choosing any kind of decision among alternatives.	When the number of the levels in the hierarchy increase, the number of pair Comparisons also increase, so that to build the AHP model takes much more time and effort.

AHP provides a way to rank the alternatives of a problem by deriving priorities. AHP gives a proven, effective means to deal with complex decision making and can assist with identifying and weighting selection criteria, analysing the data collected for the criteria and expediting the decision making process. AHP has been shown to be a robust method of eliciting and using multi criteria preference relationships in a range of applications. It is designed for situations in which ideas, feelings, and emotions are quantified based on subjective judgment to provide a numeric scale for prioritizing decision alternatives. The AHP is based on a matrix of pair wise comparisons between criteria, and it can be used to evaluate the relative performance of decision alternatives (for example products and services) with respect to the relevant criteria. The AHP was seen to be a suitable tool forthe purpose here, as it is a robust method that is particularly suited to decisions made with limited information (Saaty, 2000).

Baskaran R. and Krishnaiah K., 2012: Developed Bus route evaluation system, for public bus transportation system in Chennai. They design AHP model for bus route evaluation the model consist of five main criteria and eighteen sub criteria. The major criteria's are service level, operation productivity level, comfort and safety

level, socioeconomic benefit level and competence level. Conventional decision-making processes often consider quantitative criteria whereas multi criteria approach involves both qualitative and quantitative criteria. There exist processes like utility function approach to handle qualitative criteria and various optimization techniques for quantitative techniques. AHP is one such effective tool, which can handle both types of criteria. It was developed by Thomas L. Saaty in the year 1980 (Saaty et al. 1980, 1986). AHP is used for the prioritization exercise .A comprehensive bus route evaluation criteria system according to the conditions of the Indian bus transit system has been developed. These criteria are arrived at based on discussion with the bus operators and passengers and also referring to literature. The evaluation identifies the operating conditions and existing problems so as to provide an objective basis for requisite decision for regulating routes, such as withdrawing a route, or combining routes or establishing new routes, and improving service and efficiency of routes. The AHP model has the goal of evaluating the routes based on the main criteria and sub-criteria. The required quantitative and qualitative data have been collected from the seven routes of a depot of Metropolitan Transport Corporation (MTC), Chennai in India. MTC cover an area of around 1177 square kilometres with 500 routes controlled by 25 depots. Around 37 lakh passengers travel per day in MTC buses. The data are collected from the passengers travelling in the route and the officials working in the depot of MTC.

Fuzzy analytic hierarchy process (FAHP) first appeared in van Laarhoven and Pedrycz (1983).Previous studies have evaluated FAHP as applied to the overall issue of selection (e.g. facility, vendor or building (Bozda et al., 2003; Kahraman et al., 2003), supplier selection and project selection (Huang et al., 2008). These different selection processes have all benefited from FAHP and have a common characteristic: the degree of fuzziness in human decision making is fixed. They do not take into account the fact that the degree of fuzziness can vary depending on the criteria being considered.

III. NEED OF STUDY

Public Transport System in most Indian cities is rapidly deteriorating because of the increasing travel demand and inefficient transportation system. Due to inefficient public transport system in India various problems like Accidents, Environmental degradation, Congestion, and Overcrowding have increased. Some studies conducted on BRTS mainly concentrated on particular corridors which raise challenge to safety of traffic (Jaiswal et.al,2012) whereas some studies point out the increase in revenue after the implementation of BRTS (Agarwal et. al.,2010).There are also some studies which have investigated the characteristics of BRT and how it compares with other modes in terms of cost and implementation(Jaiswal et.al, 2012; Hildalgo et al., 2013).The parameters like Quality, Quantity and Financial is not given proper attention in the evaluation methods. It is necessary to evaluate the performance of BRTS in existing cities to know how well it is providing transport service in terms of these parameters so that valuable information can be obtained and important operating decisions can be taken.

IV. OBJECTIVE AND SCOPE OF STUDY

The Main objective of this study is to develop analytical hierarchical structure for performance evaluation of BRTS system

V. SCOPE OF STUDY

To meet the above objective, scope of this study is limited to-

- Review of Literature on the Performance evaluation of BRTS
- Identification of performance indicators of BRTS
- Development of a hierarchical structure for performance evaluation of BRTS
- Determination of local and global weightage of performance indicators
- Determination of relative and absolute index of performance indicators

VI. CONCLUSION

The chapter has discussed about performance evaluation practise existing in India and other parts of world.

- The detailed study conducted on BRTS is mainly concentrating on particular corridors which raise challenge to safety of traffic (Jaiswal et. al 2012)
- Major studies point out the increase in revenue after the implementation of BRTS.
- Most studies uses parameters like safety (Wright.L.; 2004 and Jaiswal et. al 2012), cost(Jaiswal et. al 2012) and Environmental impacts (Wright.L.;2004 and Jaiswal et. al 2012).
- The indicators are not grouped under any category and Quality, Quantity and financial perspective evaluation is not done.
- Inconsistency in judgment in survey was not consider means that in many practical cases the human preference model is uncertain and decision-makers might be reluctant or unable to assign exact

numerical values to provide exact pairwise comparison judgements so fuzzy AHP is used to rectify small inconsistency in survey.

- AHP pair-wise comparison process has been improved in the fuzzy AHP and gives the results using fuzzy numbers and linguistic variables to achieve accurate result.

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