Users' Perception About Importance of Operational Parameters of Bus Rapid Transit: An Application of Analytical Hierarchy Process

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Abstract: - BRT is a fast, efficient and high-quality public transport system, implemented in a large number of cities around the world. However, there are specific gaps found in the relevant literature including limited focus on developing countries, neglect of smaller urban contexts, and lack of deploying appropriate techniques to analyse user perception. This research focuses on the determination of the users' perspective with regarding travel cost, time and comfort for different trips length ranges, by comparing Metro bus system in Multan Pakistan with the existing modes of buses and rickshaws. In this regard, Metro Bus System Multan South Punjab, Pakistan is compared with other available public transport options. Considering the above-mentioned criteria, Analytical Hierarchy Process (AHP) was used to check the priority of BRT, Non-BRT Bus, and Rickshaws. As part of AHP, weightage of criteria is also computed to know the extent of user preference while planning a new BRT System in any region having similar demographics as the study area. It is revealed that passengers much prefer the BRT over the other alternatives i.e. Non-BRT Bus and Rickshaws for all travel ranges. Most importantly, the analysis highlighted a dramatic shift in user priorities. Wherein, travel time was paramount for trips up to 10 km evidenced by a time-cost trade-off value >12. While passenger comfort became the primary factor with a comfort-time trade-off value of 2.6 for longer trips (15 km+). These trade-offs provide clear guidance regarding BRT system design and operational policies which must prioritize travel time reliability for shorter corridors and passenger comfort for longer routes. The study provides important guidelines for increasing the ridership of current BRT systems and their future planning and design.

Key-Words: - bus rapid transit, travel time, travel cost, comfort, analytical hierarchy process, passenger preference

Received: December 8, 2025. Revised: March 11, 2026. Accepted: April 12, 2026. Published: June 25, 2026.

1 Introduction

Bus Rapid Transit (BRT) is gaining attraction as an efficient and effective mass transit system since the past two decades [1]. Recent studies have shown many competitive advantages for BRT systems, compared to traditional modes of public transportation, including economic growth, passenger's satisfaction, better services for elderly and disabled, integration with feeder services, better access to suburban areas and cost effectiveness. Due to these reasons, BRT has been getting worldwide acceptance with employment in more than 200 cities [2]. Low-cost BRT projects are usually more cost effective as compared to Light Rail Transit (LRT) or Heavy Rail Transit (HRT) in the major cities with populations in access of 500,000 [3]. According to the scoring system developed by the Institute of Transportation and Development Policy (ITDP), the BRT's infrastructure is categorized into four classes Basic, Bronze, Silver and Gold BRT. The said standards have also been adopted in Pakistan [4].

Vehicle ownership and traffic congestion, in rapidly emerging economies and developing countries, are making them invest in high capacity, highly efficient transit systems. According to UN Habitat [5], between 2013 to 2030, most of the 2 billion new dwellers will be in cities having population of 100,000 to 500,000 [6]. These cities experiencing severe traffic congestions issues with financial repercussions. A study conducted in 2014 for Pakistan reported the congestion related costs to be as high as USD 1 Billion for mega city of Karachi while USD 0.03 Billion Karachi for a relatively smaller city of Multan [7]. In addition to that, other externalities such as road accidents and environmental degradation are urging the need to adopt sustainable transportation solutions in the form of BRT which has proved to be effective in catering these issues in other countries. The example of China is available in this regard which has reaped benefits of BRT systems in its various major cities including Beijing, Kuming, Jinan, Hangzhou, Chengdu, and Xi'an [8].

The safety impacts of BRT are linked with the reduction in traffic, mixed traffic, and speeds of private vehicles due to infrastructure modifications to facilitate BRT movement [9]. Limited literature is available on the evaluation of safety (Road Crashes & Injuries) after the implementation of BRT. Therefore, there is room for more empirical studies so that decision makers may use literature in future decisions [10].

Despite the importance and increasing popularity of BRT systems in developing countries, research related to them is of critical nature, especially for Pakistan. Moreover, the end-user perspective is a critical factor in the feasibility and operation of such systems. Therefore, this research aims to bridge this gap quantitatively modelling the relative importance of key operational factors of time, cost and comfort from the end-users' perspective in a typical secondary Pakistani city. The Analytical Hierarchy Process (AHP) technique is employed to rank these factors and also to derive precise priority weights and trade-off ratios, offering deeper insight into the decision-making process of travelers when choosing between formal and informal public transportation modes. By covering these aspects, this study makes several key contributions. Firstly, it quantifies a critical shift in user priorities from travel time dominance for shorter trips to comfort preference for longer journeys. Secondly, it provides comparative, quantified insights comparing BRT with dominant informal modes (auto-rickshaws) and traditional buses. Finally, it applies AHP to this context which helps in delivering actionable trade-off ratios for planners. Furthermore, it highlights context-specific social constraints, such as limited female mobility, that are critical for equitable transportation planning.

2 Literature Review

2.1 Operational Performance of BRT

The BRT system has been reported to have an edge, in terms of cost effectiveness and efficiency, over other modes of public transportation, such as, street bus, LRT and HRT [11]. The addition of an exclusive bus lane for BRT not only reduces the travel time for BRT users but also reduces traffic load in the other lanes of road with the reduction private vehicles and avoidance of mixed traffic conditions. Moreover, efficient ticketing systems, coupled with latest technology further improves the efficiency of the performance of BRT system [12].

BRT has a high effect on the associated land development. In most of the cases, areas which are served by BRT had more land development activities as compared to other areas. The prices of land and its availability have changed a lot due to the operation of a BRT line along the area. A previous study which was conducted to evaluate the impacts of land development due to intrusion of BRT in Quito and Bogota found that a considerable development was observed in land use, road expansions, availability of land, land regulations and market conditions [13].

Equitable accessibility is another important aspect of public transportation systems. They should be providing equal opportunities to different sects of the society including people with disabilities and elderly. In this regard, the BRT system is reported to provide an easy access to people of different backgrounds and abilities [14].

Time is a factor that affects both cost/earning as well as productivity of a human being [15]. Its importance has become more prominent in the modern fast-paced era [16]. Travel cost for public transportation for the passenger is mainly based upon the fare. Considering the fact that these systems are mainly used by low and middle income groups of the society for their work/study, it becomes a critical aspect of their decision making process [17].

Travel Comfort is a broader term which encompasses several items including ease of accessibility, better station and bus facilities and linkage to the feeder systems [18]. The consideration of comfort is expected to be more critical for longer trips or trips requiring multiple transfers.

There have been a number of studies which have dealt with the issue of performance evaluation of an urban mass transit system. They have used a variety of factors liked with the system users like fares, comfort, reliability, frequency, travel time, cleanliness etc., [19]. Passenger satisfaction surveys have been found to be collected and analyzed in this regard. A study in Beijing, China has found a very satisfaction level of the passengers towards the bus service [20]. In another study, Ingvardson and Nielson have also studied 86 mass transit systems around the world and found that impacts of mass transit networks mainly depend upon travel times, service frequency, comfort, and accessibility around the stations [21].

Gender equality is another sensitive issue related to public transportation systems, especially, in the context of Pakistan due to its unique religio-social settings. Zolnik et al. [22] have found that women travelers BRT system in Lahore was found to be a more preferred mode of transportation by the women travelers who also take great benefit from the subsidized fare [22].

2.2 Public Acceptance of BRT:

One of the key components of the success of BRT is the public acceptance of this service for its feasibility and future sustainability. It is important that the users should perceive the utility, efficiency and ease with the use of BRT for them to shift from their present modes to it [23]. Previous experience has shown that BRT systems have faced community resistance when the important factors, affecting the public have not been taken into account [24]. The issue has been widely acknowledged at the highest level, so much so that Asian Development Bank (ADB) has based its ranking for sustainable transport systems on users' perception [25].

The issue of users' perception can be peculiar to certain cultural and geographic settings due to vast differences in people belonging to different regions and backgrounds [26]. For a developing country, such as Pakistan and Columbia safety from criminal activities could be a strong factor influencing the mode choice including BRT [27]. Due to the higher investments being involved and vast differences in the operation, some researchers also felt the need to compare the acceptance of BRT with other modes of public transportation. One of those studies found that the acceptance level varies even within the same country due to factors of affordability and accessibility [28]. Another study emphasized the need to evaluate the impacts of different sustainable transportation options from the users' perspective for better comparison. The study also found that the different projects may be perceived negatively from one aspect and positively from the other [29].

The implementation of BRT systems in South Asian cities has been met with a wide spectrum of user perceptions. The analysis of empirical evidence from various urban centres concludes the following. Positive user perceptions are consistently tied to demonstrable improvements in safety, security, and accessibility, particularly for women and disabled populations, as well as the system's ability to deliver reliable, time-saving, and cost-effective services [30]. Conversely, negative public sentiments generate from poor project implementation, design flaws that exacerbate existing traffic problems, and a failure to address the needs of non-BRT users [31].

Couple of studies of this nature have been done in Pakistan. In Multan, Pakistan, around 54% of passengers expressed high satisfaction with the BRT system, primarily due to comfort [32]. The BRT system in Lahore, Pakistan, also revealed differences in travel characteristics and satisfaction levels among users, highlighting the importance of addressing service quality attributes [33].

BRT has also been implemented in a number of cities in India wherein researchers have looked into the aspect of its acceptance. In Navi Mumbai and Surat, India, users prioritized bus stop waiting time, on-time performance, and in-vehicle travel time over other factors like riding comfort and safety [34]. Similarly, in Ahmedabad, India, key service quality attributes included both on-board and off-board measures, with user expectations linked to existing service quality levels [35]. Dhaka, from Bangladesh, is another major city in South Asia. A study carried out in this city by carrying out a stated choice survey indicated that males, older workers, and those with higher education and income levels were more likely to choose BRT [36].

BRT systems in the Global South, including South Asia, have shown benefits for low-income groups in terms of travel time and cost savings. Hence, these parameters are found to be critical for users from this income group as well as medium-income group [37].

Safety, particularly for women, is a significant concern in public transportation in the South Asian context due to the cultural values. In Ahmedabad, India, factors such as travel experience and physical infrastructure condition influenced women's safety perceptions on BRT and other public buses [38]. In Bangladesh, harassment on public transport remains a critical issue, with significant gender differences in perceptions of safety and mobility hindrances [39].

These insights from various studies across South Asia highlight the importance of understanding user perceptions and addressing key factors to improve the effectiveness and adoption of BRT systems.

2.3 Present Study

The above review highlights a few important points. First of all, the importance of operation factors is established which includes the travel time, cost and comfort. Secondly, the critical issue of user acceptance plays a vital role in feasibility of BRT systems and its use on a large-scale. Lastly, the user acceptance cannot be generalized across the globe, hence, there is a need to conduct region specific studies in this regard. This is especially true in the case of Pakistan which has experienced substantial changes in the last decade due to introduction of BRT systems in various cities.

Considering these findings from literature, three factors have been chosen to compare the public transportation options in the study area. These include, Travel Time, Travel Cost and Travel Comfort, which are reported to heavily influence the end users / passengers in their mode choices. Responses from users have been collected and analyzed to determine their preference in mode collection in reference to these factors. The preferences have been quantified using weighing scales to facilitate the use of the results for planning of future BRT systems in conditions similar to the study area. The review of literature clearly shows that the prioritization of the operational factors of BRT during planning and implementation of a new BRT system would maximize its benefits for the society [40].

While several studies have assessed BRT performance in terms of service quality and passenger satisfaction (as mentioned previous in this section), few have systematically prioritized user perception factors using AHP in South Asian cities. Moreover, earlier studies rarely examined the interplay between BRT and informal modes such as rickshaws or acknowledged cultural factors limiting female participation. This study fills these gaps by applying AHP to evaluate user preferences in a Pakistani urban context. Moreover, there is a lack in the studies which quantify the importance of factors affecting the choice of BRT by the users, especially for smaller urban areas in developing countries such as Pakistan. The current study also caters this aspect.

3. Brief Introduction to Multan Metro System

Multan is one of the oldest cities in Pakistan and has a large number of mausoleums and shrines [41]. Multan has become the political and economic center of the Southern regions of the Punjab [42]. As shown in **Fig.** 1, it has excellent transport links across the country due to its strategic location. It is connected to the national highway network with multiple major highways including N-5, M-4 and Lahore motorway. Multan is the 4th largest city of Punjab with a population of approximately 2 million [32]. Due to its importance, a long-term mass transit network for Multan was proposed. Salient characteristics of Long-Term Mass Transit network are shown in Table 1, and their locations can be seen from **Fig.** 2. The construction of the Red Line was completed in December 2016 with a capacity to carry 93000 passengers per day.

Table 1. Salient features of the long-term mass transit network

Mass Transit Lines	Line Length (km)			Number of Stations		
	Elevated	At-Grade	Total	Elevated	At-Grade	Total
Red Line	11.87	6.65	18.52	14	7	21
Red Line Extension	0.44	2.53	2.97	0	4	4
Orange Line	8.4	6.4	14.	12	5	17

	9	5	94			
Purple Line	8.65	10.39	19.04	14	12	26
Blue Line	10.79	5.55	16.34	11	5	16
Total	40.7	30.69	71.39	51	33	84

The total length of the BRT route is about 18.5 km with 21 stations and an average distance of around 880 m between stations. This route is physically separated from regular roadway through a fence. The BRT Multan provides commuter services to the city residents seven days a week between 6:15 am to 10:00 pm. Services operate at average frequencies of [5–10 minutes during peak], with standard and articulated buses offering seating for 190 passengers. The flat subsidized fare for this service is 20PKR (approx. USD 0.07), which makes it competitive with auto-rickshaws and minibuses, which dominate as alternative modes. The Multan Metrobus System has eleven feeder lines proposed by the Punjab Masstransit Authority. The feeder lines complement the Metrobus Line regarding the operation, pricing, and physical integration. Moreover, the demand-responsive transport, including online taxi services, also provides services to the citizens, serving as the key for door-to-door connectivity with the metro bus.

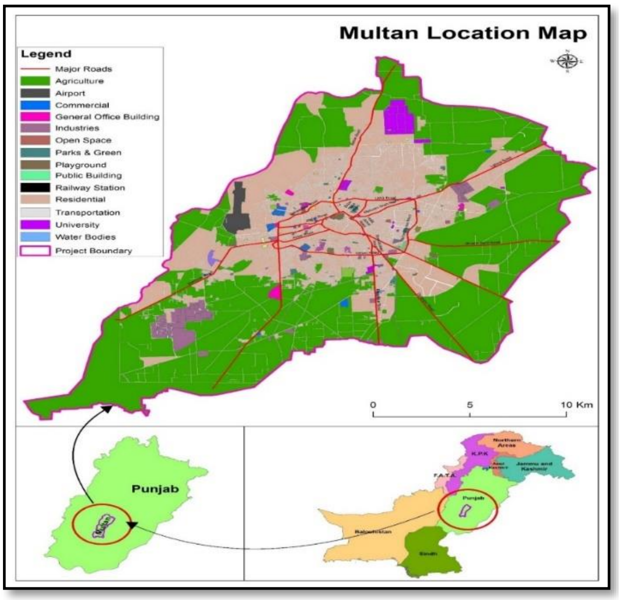

Fig. 1. Location of Multan

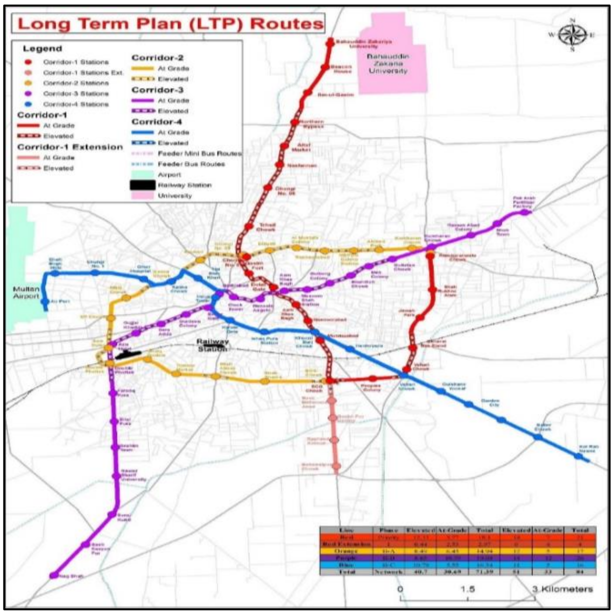

Fig. 2. Routes of BRT in Multan

4. Data And Methodology

The aim of this research was to find out the acceptance of the BRT system by the end user as compared to other public transport modes, including traditional bus and Qingqi Rickshaws, using travel time, cost and comfort.

4.1. Analytical Hierarchy Process (AHP)

Analytical Hierarchy Process (AHP) was used to analyze the passengers' choice criteria for the public transportation systems. This process was selected due to its advantage of providing the priority percentage for the indicators used to make decision [43]. **Fig.** 3 provide the working diagram of the process to understand its application in this research.

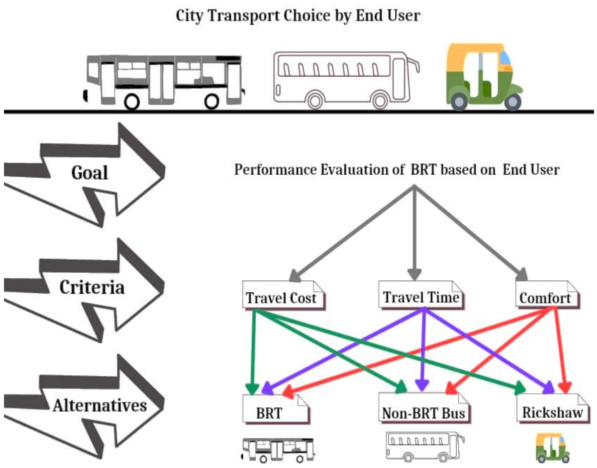

Fig. 3. Working diagram of AHP

In this process, the goal is to determine the priorities of the alternatives with respect to decision criteria and also the priority of each criterion is determined to indicate the relative strength of the criteria [44]. In the current research, the goal is to evaluate the performance of BRT with respect to the end user. It was evaluated based on Travel Cost (Fare), Travel Time & Travel Comfort. The alternatives included BRT, Non-BRT Bus Service (Traditional buses) and (Qingqi) Rickshaws. In addition to priorities for different factors, combined priorities were also calculated to determine the preference of alternatives.

All the priorities and alternatives are the ratio of weights between two alternatives, let us say i and j (Wi/Wj) given by the respondent [45]. These priorities are arranged as a 2-d matrix, for which samples are provided in Tab. 7 and 8 for the current research. A standard scale is used to convert the linguistic interpretation of priorities to their corresponding numeric values, which is shown in **Table 2** [46].

Table 2. Scale of pairwise comparison

Intensity / Importance	Linguistic Definition	Explanation
1	Equal importance	Both modes are contributing equally to the criteria
3	Moderate importance	Experience and judgement moderately favors one option over the other
5	Strong importance	Experience and judgement strongly favors one option over the other
7	Very strong importance	Experience and judgement very strongly favors one option over the other such that its dominance is demonstrated in selection
9	Extreme importance	Experience and judgement favors one option over the other to the extent of highest order of affirmation

The comparative rankings given for each alternative, in a pair, can be used to calculate a priority matrix (p) as per equation (1) (Ishizaka and Labib 2011).

$$A. \quad p = \lambda max. \quad p \tag{1}$$

Where,
A = is the comparison matrix
p = is the priorities matrix
λmax = maximal eigen value

In view of the above-mentioned, questions were designed as simple as scale elaboration so that the same may be easily understood by the end users and as accurate as the requirements of the scale. For example: while comparing Travel Cost vs Travel Time, the following options (Shown in Table 3) were given against each of the different travel ranges, where the end user has to choose any one option.

Table 3. Sample of Options Given for Comparison

Both have equal importance
Cost is moderately important than time
Cost is strongly important than time
Cost is very strongly important than time
Cost is extremely important than time

4.2 Sampling and Survey

A survey was required with suitable sample size for conducting the analysis of the study. Data were collected through on-site surveys at selected BRT stations across peak and off-peak hours during December 2021 to January 2022. Respondents were approached using convenience sampling. As stated earlier, the number of users in the peak hours are reported to be 90,000. Therefore, the sample size was calculated by assuming the population size of 100,000 with a confidence level to 95%, and margin of error of 5% and sample proportion (p) of 50%. equations (2) and (3) were used to calculate the sample size which came out to be 400 (Israel 1992).

$$n=N*X/(X+N-1) \tag{2}$$

Where,

$$X = Z\alpha/22 *p*(1-p) / MOE^2 \tag{3}$$

A questionnaire was designed according to the scale in Tab. 2 for the factors and modes considered in this study. Considering the demographics and ease of respondents, the questionnaire was designed in both English and Urdu languages for effective and accurate results. Also, the scale of comparison in Tab. 2 was briefed at the start of the questionnaire for ease. Travelers' characteristics i.e., Name, Gender, Cell No., Age, Education, Income and Location were required, however, information about Income level and Cell No. were kept optional. The survey was conducted at 25 locations around the periphery of BRT Multan or Feeder Bus Corridor.

The travel distances were considered in three (03) different ranges i.e., 1 to 5KM, 1 to 10KM and 1 to 15 KM. 396 out of 400 filled questionnaires were received and were used for evaluation using the AHP.

4.3 Description of The Sample

As already mentioned, a sample size of 400 was collected for analysis, 25 different locations including Multan BRT stations and Major Bus Stops were selected to get the questionnaire filled. The questions related to the respondent were intentionally kept to a minimum to curtail the time required to fill the questionnaire as the other questions involved pair-wise comparison would require considerable time. The data collection team briefed the respondents on how to fill out the questionnaire for ease of the respondents. Later it was analysed that 82% males and 18% females have participated in responding to the questionnaire having average income of approx. 22,500/- PKR. This is due to the fact that male respondents are easy to approach as compared to females in the local culture. Although efforts were made to reach diverse user groups, cultural constraints limited female participation, resulting in a male-dominated sample. This limitation reflects a broader cultural issue in Pakistan, where women's mobility is often restricted. This particular limitation, while reducing representativeness of the sample to the actual population, highlights a critical reality for transport planning. Most of the respondents belong to Multan and its sub urban areas. Also 18% of the total respondents were students and have no income source. The average age of the respondents was 25 years, ranging from 17 to 64 years.

It is acknowledged that the convenience sampling approach, coupled with cultural restrictions, may introduce bias and limit generalizability. However, the AHP framework is particularly robust for capturing relative priorities among respondents. Therefore the analysis is expected to be valid for drawing insights into user perceptions [47].

4. Results

A pairwise comparison was made between the different modes of public transportation and rickshaws based on the Travel Cost, Travel Time, and Travel Comfort for three travel ranges i.e., 1-5KM, 1-10KM and 1-15KM. Similar comparisons were also made between Travel Cost, Travel Time, and Comfort. Consequently, a total of 36 comparisons with 12 consistency matrices were developed.

Analytical values were assigned to the parameters accordingly. One of the matrices along with calculation is shown in Table 4 below for reference.

Table 4. Sample calculations for AHP matrix

Criteria	Range	Priority Vs Goal	Alternative	X	Y	Z=X*Y
Travel Cost	1-5 km	0.064	BRT	0.110	0.064	0.007
			Non-BRT	0.309	0.064	0.020
			Rickshaw	0.581	0.064	0.037
	5-10 km	0.060	BRT	0.333	0.060	0.020
			Non-BRT	0.333	0.060	0.020
			Rickshaw	0.333	0.060	0.020
	10-15 km	0.052	BRT	0.620	0.052	0.032
			Non-BRT	0.224	0.052	0.012
			Rickshaw	0.156	0.052	0.008
Travel Time	1-5 km	0.669	BRT	0.648	0.669	0.433
			Non-BRT	0.122	0.669	0.082
			Rickshaw	0.230	0.669	0.154
	5-10 km	0.750	BRT	0.738	0.750	0.554
			Non-BRT	0.168	0.750	0.126
			Rickshaw	0.094	0.750	0.071
	10-15 km	0.263	BRT	0.800	0.263	0.211
			Non-BRT	0.124	0.263	0.033
			Rickshaw	0.075	0.263	0.020

Comfort	1-5 km	0.267	BRT	0.794	0.267	0.212
			Non-BRT	0.067	0.267	0.018
			Rickshaw	0.139	0.267	0.037
	5-10 km	0.190	BRT	0.767	0.190	0.145
			Non-BRT	0.174	0.190	0.033
			Rickshaw	0.059	0.190	0.011
	10-15 km	0.685	BRT	0.767	0.685	0.525
			Non-BRT	0.174	0.685	0.119
			Rickshaw	0.059	0.685	0.040

To check whether all the comparisons are consistent with each other or not, a "Consistency Check" must be performed as per equation (4) and Table 5. The consistency ratio was found to be 0.001. While a ratio of less than 0.01 is considered satisfactory to prove that the survey responses are consistent [48].

Consistency Ratio=(λmax-n)/(n-1)(RI) (4)

Table 5. Consistency check

A				W	A*W	λ_{max} = A*W/W
Travel Cost	BRT	Non-BRT	Rickshaw	Priorities		
BRT	1.00	0.33	0.20	0.11	0.33	3.001
Non-BRT	3.00	1.00	0.50	0.31	0.93	3.004
Rickshaw	5.00	2.00	1.00	0.58	1.75	3.006
					Avg:	3.004

Where n is the number of options and Randomness Index has constant values for size of matrices like it is 0 for matrix sizes of 1 and 2, 0.58 for matric size 3, 0.9 for matric size 4 and so on, reference [49] can be checked for more details on this aspect.

Similarly, pairwise comparisons between the criteria were formed to get the weightage of each criteria. One of the samples is shown in Table 6, for reference.

Table 6. Criteria vs criteria w.r.t reaching the goal

Criteria	Matrix Fraction			Preference Vector			Priorities
	Travel Cost	Travel Time	Comfort	Travel Cost	Travel Time	Comfort	
Travel cost	1	1/9	1/5	0.067	0.077	0.048	0.064
Travel Time	9	1	3	0.600	0.692	0.714	0.669
Comfort	5	1/3	1	0.333	0.231	0.238	0.267

In this way, 12 preference and consistency matrices (as shown in Tab. 4) have been formed and solved mathematically to get the results shown in Table 7.

Table 7. Overall priorities

Travel Cost	Matrix Fraction			Preference Vector			Priorities
	BRT	Non-BRT	Rickshaw	BRT	Non-BRT	Rickshaw	
BRT	1	1/3	1/5	0.111	0.100	0.118	0.110
Non-BRT	3	1	½	0.333	0.300	0.294	0.309
Rickshaw	5	2	1	0.556	0.600	0.588	0.581

Table 8 shows the total weight of the factor calculated as part of the AHP process for each factor as well as mode of transport under study. It is shown in Table 8 that for 1-5 km travel distance, the preference is in the order of BRT > Rickshaw >

Non-BRT, while it is BRT > Non-BRT > Rickshaw for 5 km and above. The general preference for BRT by the travellers was also observed in another study done in Faislabad, Pakistan [50]. Moreover, the preference and suitability of rickshaws for shorter distances was also found in previous study for the study area (Multan) by [51]. This is linked with the capacity and speed of rickshaws which make them highly unsuitable for longer travel distances.

Table 8. Priorities w.r.t. (%)

		Travel Cost	Travel Time	Comfort	Total
1-5 km	BRT	1%	43%	21%	65%
	Non-BRT	2%	8%	2%	12%
	Rickshaw	4%	15%	4%	23%
	Total	6%	67%	27%	100%
5-10 km					
	BRT	2%	55%	15%	72%
	Non-BRT	2%	13%	3%	18%
	Rickshaw	2%	7%	1%	10%
	Total	6%	75%	19%	100%
10-15 km					
	BRT	3%	21%	53%	77%
	Non-BRT	1%	3%	12%	16%
	Rickshaw	1%	2%	4%	7%
	Total	5%	26%	68%	100%

In terms of trip features, the order of preference was Travel Time > Travel Cost > Comfort for distances up to 10 km. Moreover, Travel time got the highest priority of more than 65%. These results differ from [52], where travel cost ranked highest for shorter distances in China. There is uniqueness in the preference made by the end user in terms of criteria for 10-15 km. It is shown that user prefers Comfort > Travel Time > Travel Cost. Hence, it could be concluded that with the increase in travel distance, the user's preference more likely goes towards comfort. This prioritization aligns with findings from [53] in France.

5. Discussion

5.1 Key Findings

The above analysis provides valuable information regarding the users' perceptions of the public transport modes with regard to their operational characteristics. The success of the consistency check validates the results from the AHP. It is clearly shown that the users' priorities change with respect to travel distances. However, BRT has the highest priority in all cases while travel cost has the least priority in terms of factors irrespective of the distances. These findings are further reinforced by the fact that BRT operates on subsidized fares, which makes it on-par with the other modes of public transport. It is intuitive that the travel cost will not have much impact when the private modes of transport are not considered. Consequently, travel time and comfort take higher precedence from users' perspective, in which case BRT is superior to other modes of public transport which explains its higher priority for all ranges of travel distances.

Another interesting finding is that travel comfort takes the highest priority for longer trips. This could also be explained by the fact that users are already prepared for longer travel times when their trips are longer in terms of distance. Hence, they would place higher emphasis on comfort.

5.2 Policy Implications

The results of this study provide several insights into how BRT users in Multan, Pakistan perceive different attributes of the system, which can be used to make informed improvements in public transport services. The Analytical Hierarchy Process (AHP) allowed for a structured prioritization of user preferences, highlighting travel time reliability as a dominant factor with comfort being preferred for mode choice in case of longer distances for mode choice. Importantly, these findings echo prior studies on BRT systems in developing countries while also revealing context-specific dynamics relevant to Pakistan.

Another key observation is the trade-off between affordability and service quality. While the subsidized fares of BRT were at-par compared to alternative modes (e.g., rickshaws), users also emphasized expectations for comfort and travel time reliability. This reflects the challenge for operators and regulators to provide a balance between fare subsidies and cost controls against investments in vehicle quality, frequency of service, and maintenance. A sustainable policy approach should ensure that affordability does not come at the expense of deteriorating service standards.

The findings also draw attention to the role of informal modes such as rickshaws, which continue to exert significant modal competition despite the introduction of BRT. Respondents' perceptions suggest that while BRT is valued for cost and capacity, rickshaws retain an edge for shorter distances due to their flexibility and accessibility. This underscores the importance of integrated planning where BRT corridors are complemented by regulated feeder systems with the integration of existing modes.

From a governance perspective, the study emphasizes the role of user perceptions as key performance indicators for system evaluation. Local transport authorities and private operators should embed perception-based surveys and multi-criteria decision tools, such as AHP, into their regular monitoring frameworks to make targeted service quality improvements grounded in actual user priorities. This approach will improve their legitimacy and will have the desired responsiveness from the travellers.

Although the AHP was not designed to estimate monetary value of time, the relative weights could suggest how riders trade one attribute for another. For example, the ratio Time–Cost trade-off (≈*w*time/*w*cost) indicates how strongly a proportional improvement in travel time is valued relative to a proportional change in fare.

Similarly Comfort–Time trade-off (≈*w*comfort/*w*time), offer a qualitative sense of whether crowding/ride quality improvements could rival minute-level time savings in perceived benefit. These ratios, derived directly from Table 8, help interpret which operational levers are likely to move satisfaction most in this corridor.

These trade-offs are shown in Table 9. A Time-Cost trade-off value of 11.17 for the 1-5 km range means users value an improvement in travel time over 11 times more than a similar proportional change in cost. This priority for time over cost is strongest for medium distances (5-10 km). For the 10-15 km range, a Comfort-Time trade-off value of 2.62 indicates that users value an improvement in comfort over 2.6 times more than a similar proportional improvement in travel time. For short trips, time savings are still more valued than comfort gains.

Table 9. Relative Trade-off Weight

Travel Distance Range	**Time–Cost Trade-off**	**Comfort–Time Trade-off**
1-5 km	11.17	0.40
5-10 km	12.50	0.25
10-15 km	5.20	2.62

These trade-off ratios provide a quantitative basis for the observed user priorities. They reinforce the critical policy challenge of balancing subsidized fares with service quality investments. For shorter corridors, the planners must aggressively prioritize travel time reliability through traffic signal priority and lane enforcement. For longer routes, the focus must shift to investments in vehicle comfort, crowding reduction, and station amenities. This recommendation is based on the pivotal shift in comfort trade-off which was more than twice as much as travel time savings. These ratios offer clear guidance for allocating limited operational budgets to the improvements based on user perceptions to have maximize the ridership.

5.3 Limitations and Future Work

The analysis of this study intentionally focused on travel time, cost, and comfort. Attributes such as safety, security, or network coverage were outside scope and are therefore not interpreted here. The results are also conditioned by our sample and study period; nevertheless, the AHP priorities provide an actionable ordering of improvements within the bounds of the available data.

Subsequent studies can extend the framework by adding safety and reliability as separate criteria and by testing the shift in priorities across time-of-day or user groups. Those extensions lie beyond the present study's scope but would complement the three-attribute structure used in this study.

6. CONCLUSION

This study quantified the relative importance of key operational parameters influencing user preference for BRT in a typical South Asian context for a smaller urban area. By doing so it addressed a critical research gap in the context of developing countries. By applying the Analytical Hierarchy Process (AHP), it not only confirmed BRT as the most preferred mode but also offers insights about dynamic shifts in user priorities across different ranges of travel distance. This study takes up this task by providing a quantitative importance metric for the system characteristics related to public transport. Evaluation of results showed BRT as a highly preferred public transport system among the public transportation alternatives. Furthermore, the parameters which influence the users' decision were also analysed, these parameters included Travel Cost, Travel Time and Travel Comfort.

The results demonstrate a clear dichotomy in user priorities. For short to medium distances (1-10 km), travel time is the paramount factor for users, with a Time-Cost trade-off value exceeding 12 indicating its overwhelming importance over fare. Conversely, passenger comfort becomes the primary concern for longer distances (10-15 km) with a Comfort-Time trade-off value of 2.62. This means that users value comfort improvements more than twice as much as equivalent travel time savings. These findings provide a quantitative framework for planners and policymakers. The high trade-off values suggest that for shorter BRT corridors, investments must be directed towards travel time reliability. While for longer routes, the focus shifts strongly towards investments in ride quality and comfort. This prioritization is crucial for efficient resource allocation in budget-constrained environments of developing Asian countries. It is assessed that the BRT corridor is usually designed for longer distances i.e., around 15 km or more, rather than for shorter distances. The investments in BRT systems are highly justified based upon the comfort level provided by them, especially for longer distances. The findings of this study are expected to be beneficial for transportation planners and policymakers by providing them with important guidelines related to operational parameters. These insights can be used for improving the operation of BRT systems as well as planning and design of future systems.

Beyond its methodological application of AHP to public transport user perception, this study's primary contribution lies in revealing the non-linear relationship between travel distance and user priority. The priorities were quantified through clear trade-off ratios. This underscores the necessity for context-sensitive, distance-based service quality standards rather than a generic approach. The results emphasize the need for transport policy to address reliability, and comfort in tandem. Despite limitations, the study demonstrates the value of AHP in prioritizing user needs and provides a reference point for similar developing country contexts.

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Contribution of Individual Authors to the Creation of a Scientific Article (Ghostwriting Policy)

All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by Muhammad Wajid Saleem, Muhammad Waseem and Bilal Khalid. The first draft of the manuscript was written by Uneb Gazder and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

Sources of Funding for Research Presented in a Scientific Article or Scientific Article Itself

No funding was received for conducting this study.

Conflict of Interest

The authors have no conflicts of interest to declare that are relevant to the content of this article.