ASSESSING PUBLIC TRANSPORTATION PREFERENCE: AN ANALYTICAL HIERARCHY PROCESS APPROACH

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ABSTRACT

As urbanization keeps growing, the demand for efficient and sustainable conscious transportation solutions increases. Public transportation systems are essential since they provide alternatives to driving a private vehicle. Policymakers and transportation planners must comprehend the factors influencing people's preferences for public transit. This study employs Analytical Hierarchy Process (AHP) approach to identify and rank the major variables determining preference towards public transportation. This research makes use of a structured questionnaire survey administered to a diverse sample of commuters from various demographic segments. The respondents are asked to rank the several factors including travel cost, travel time, frequency, reliability, transit station condition and various service quality attributes, based on their importance in influencing their choice of transportation mode. Through pairwise comparisons and mathematical computations facilitated by AHP, the relative weights of each criterion are determined, providing insights into their significance in shaping public transportation preference. The study findings contribute to improving the effectiveness of public transportation planning and policy design by highlighting areas for development. Authorities can encourage more use of public transit by aligning transportation services and infrastructure to commuters needs and preferences thus, mitigating traffic congestion, reduce carbon emissions and promoting sustainable urban mobility.

Keywords: Public transportation, Analytical Hierarchy Process (AHP), Consistency Ratio

1.Introduction

Public Transportation also called as public transit, public transport and mass transit plays a crucial role in modern societies, offering a shared and efficient means of moving people within urban and suburban environments. Public transportation aims to make transportation services accessible to a broad segment of the population, including those who cannot afford or choose not to use private vehicles. This accessibility promotes social inclusion and economic opportunities for various demographic groups. Public transportation systems are designed to optimize travel routes and schedules, ensuring timely and reliable services. This efficiency helps alleviate congestion on roads, making transportation more predictable for commuters. Public transportation contributes to environmental sustainability by reducing the number of individual vehicles on the road. The acceptance of public transportation can be found through the factors attracting the riders. The result of the study can be used to encourage the commuters to shift from private to public transportation mode of travel. Public transport (PT) is often promoted by local governments as a sustainable mode of travel. Compared to private vehicles, PT is approximately 20 times more space-efficient [5]. Additionally, PT users can often incorporate physical activity into their journeys and it consumes less energy and emits fewer pollutants per passenger [25]. Despite these benefits, public perceptions of PT are frequently negative. Studies comparing attitudes towards different modes of travel consistently show that PT is the least preferred option, with most individuals expressing a preference for

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active modes of transportation [1],[5]. PT particularly receives low ratings regarding flexibility, convenience, predictability, and reliability [1],[5]. The disappearance of efficient and affordable public transport (PT) system, particularly extensive fleet of buses raises concern about equitable development. While private ownership of vehicles, especially two-wheelers and cars has grown at a faster rate than population growth. The introduction of PT systems is driven by the need to address various challenges associated with individual vehicle usage, such as traffic congestion, environmental concerns, and the promotion of inclusive and accessible mobility options. PT is often more cost-effective than individual vehicle ownership. The primary objectives of PT are to enhance mobility, reduce traffic congestion, and provide an affordable and accessible alternative for people who may not own private vehicle. The introduction and expansion of PT influence urban planning and development. PT is generally considered safer than private vehicles in terms of accident rates [16]. The usage of mass transit decreases air pollution, lowers greenhouse gas emissions, and mitigates the environmental impact associated with personal vehicle use. By offering affordable fare options, public transit makes it economically viable for a broader population, including students, seniors, and low-income individuals, to use PT services [17].

2. Literature Review

The use of public transport significantly reduces the environmental impact of meeting daily mobility needs. Recent research has explored the factors influencing public transport usage, identifying elements such as age, car ownership, travel distance, and parking availability as having a direct impact on an individual's choice of transport mode [26]. However, most studies have concentrated on the travel behavior of individuals in large cities, where population density is high, and public transport systems are typically more developed than in smaller cities and towns. Factors like low bus frequency and long walking distances to the nearest bus stop have been shown to negatively affect public transport use [26].

By using public transportation more frequently, dependence on private vehicles must be reduced in order to ensure transportation sustainability and ongoing economic development. However, it is impossible to find methods that effectively increase the use of public transportation if one is unaware of the key elements influencing their usage. Factors effecting choice of commuters for public transport modes are comfort, safety, reliability and cost [16]. These are considered as the main factors and again these are divided into sub-factors under each category. 'Cleanliness, air conditioning, seating availability, low floor, not crowded, accessibility', comes under main factor 'comfort' [1], [28], [8], 'Less travel time, lesser accident, personal safety, staff behaviour and attitude' comes under safety category [8], [19], [13]. 'Reliability' contains 'good frequency and adherence to schedule' as sub factors. 'Cost' means 'cost of travel', [27] and [9]. Four attributes were considered when assessing the quality of the public bus transportation system: safety, cost, speed, and cleanliness [6]. Several studies on mode selection have been conducted in various countries. Research by [7] and [18] identified factors influencing the choice of public transportation modes, such as age, occupation, salary, travel time, and travel distance. Empirical research by [15] examined the factors affecting workers' transportation mode choices in the Jakarta Metropolitan Area, considering user characteristics like private vehicle availability and income. Other factors studied included travel time, transportation costs, availability of space and parking fees. Many studies have examined service frequency and pricing as factors influencing the increase in public transport ridership. Generally, these studies conclude that increasing service frequency up to a certain point is associated with higher patronage, whereas increasing prices tends to decrease public transport usage [2]; [4]; [20]. Tangible factors are the factors that can be measurable and physical attributes that affects the operation and maintenance of public transportation system. These factors collectively determine the effectiveness, conveniences and overall

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appeal of the public bus transportation system to its users. The Table 1 below summarises all the factors influencing usage of public transport from the literatures.

Table 1: Summary table of all factors reviewed

FACTORS	SUBFACTORS	REFERENCES
Travel Cost	Ticket cost, Parking fee	(Stradling et al., 2007) and (Forman and Gass, 2001), (Dinulescu and Bugheanu, 2020).
Travel Time	Duration of journey, Waiting time for bus	(Fllesson and Friman, 2008), (Nolan, 2007), (Hensher et al., 2003) and (Debrezion et al., 2007).
Frequency	Day service of bus, Availability of bus during early and late time	Guiver (2007), (Irjayanti et al., 2021), (Balcombe et al., 2004), (Jain et al., 2014),
Reliability	Adherence to schedule, Non-frequency of breakdowns	(Stradling et al., 2007) and (Forman and Gass, 2001), (Balcombe et al., 2004)
Safety	Safety from accident , Personal safety	Dinulescu and Bugheanu, 2020), (Rasca and Saeed, 2022), (Bhat and Sardesai, 2006)
Comfort	Absence of crowdness, Cleanliness of bus, Availability of seat, Smooth drive	(Tirachini and Hensher, 2011), (Fellesson and Friman, 2008), (Hensher et al., 2003), Dinulescu and Bugheanu, 2020).
Customer service	Attitudes & behaviours of transit operators, Services provided by bus operators	(Hanumantha Rao et al., 2023), (Fellesson and Friman, 2008), (Rasca and Saeed, 2022), (Prioni and Hensher, 2000).
Transit station condition	Safety at station, Shelter from weather, Amenities at station	(Fellesson and Friman, 2008), (Forman and Gass, 2001), Dinulescu and Bugheanu, 2020).

The Analytical Hierarchy Process (AHP) developed by Thomas L. Saaty [23] is a structured technique most commonly used for finding the preferences of passengers for using PT among the various criteria [24]; [16]. The basic characteristic of the AHP method is the use of pairwise comparisons, which are used both to compare the options with respect to the various criteria and to estimate criteria weights. AHP is based on the four principles – decompositions, prioritization, synthesis, sensitivity analysis [16]. The method's simplicity of usage is its primary benefit. Because of its hierarchical nature, it is easily scalable and adaptable in size to address decision-making difficulties. Nonetheless, the approach necessitates that every component in the hierarchy be viewed as independent of every other component, including the alternatives and the choice criteria respectively [14].

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Despite theoretical and practical criticisms of the Analytic Hierarchy Process (AHP) [3], it is widely accepted and applied in practice[29]. AHP remains one of the most commonly used methods for decision support. In recent years, it has been extensively used in research related to public transportation systems [24]. Generally, AHP is known for its mathematical simplicity and reliable interpretation of research findings. It operates on an additive weighting process, representing relevant criteria through their relative importance [10]. Additionally, AHP is versatile, being employed for both individual and group decision making. [30] utilized the AHP model to identify key factors for enhancing passenger security checks at airports.

3. Methodology

3.1 Study Area

The study area chosen is the Central Business District (CBD) area within the Kottayam district. According to the 2011 census, Kottayam has a population of 1,974,551, ranking it 234th among all districts in India by population. With 28.6% of its district's inhabitants reside in urban areas. The traffic congestion at the selected CBD area is high. The number of private motorized vehicles are high in number. So, there is a need to encourage public transportation. Survey is mainly conducted at the various government offices, commercial buildings, private organisations and shops at Thirunakkara, Kanjikuzhi, Chandhakavala, Nagambadam, Baker junction and Shasthri road. The traffic congestion at the selected CBD area is high (Kottayam department of town and country planning-government report of kerala, 2011). The Figure 1 depicts the selected study area.

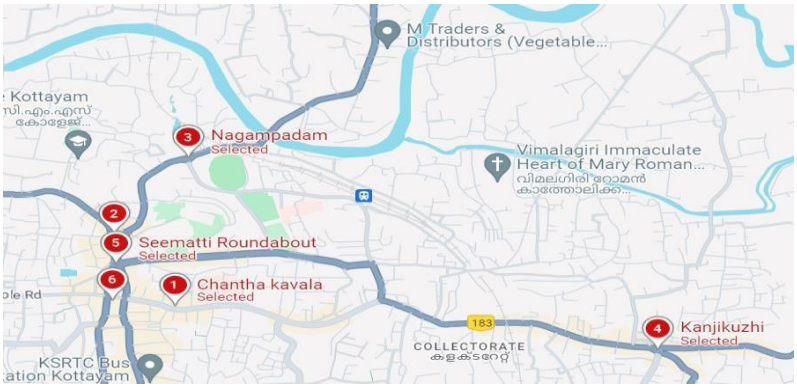

Fig1: Google map image of the study area (Source: Google image)

3.2 Data Collection

Data collection method is a crucial step in both qualitative and quantitative research. In this project, the data needed is the responses from the participants. So, the main data collection method is questionnaire survey. Effective data collection is essential for obtaining accurate and reliable data, which forms the basis for sound research findings and informed decision making. Data collection method is conducted as AHP questionnaire survey.

3.3 AHP Questionnaire Survey

After identifying the factors from various literatures study is proceeded to determine the preferences of riders influencing towards PT using AHP [24]. A well prepared AHP with all pairwise comparisons for criteria and sub-criteria are developed for this and is distributed among passengers in the study area. Total of 450 samples were collected from different category of people. The survey consists of questions related

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to the satisfaction level of each factor compared to other factor. Eight factors selected are cost, time, frequency, reliability, safety, comfort, customer service and transit station condition. Saaty nine scale [22] is used to mark the responses of passengers. This stage of survey is conducted in both offline and online.

3.3.1 Offline Survey

Conducting an offline AHP questionnaire survey is one way to get the required responses of different category of people about the importance of factors influencing them to public bus transport. Total 450 samples were collected, out of which 200 collected through offline mode.

3.3.2 Online Survey

Conducting an online AHP survey involves using digital tools and platforms to gather and analyse pairwise comparison data from participants. Google forms with a drop-down menu and sliders were provided to facilitate responses. Pilot test was conducted to refine the questionnaire and then survey was conducted. This survey included the factors and subfactors in pairwise comparison, conducting analyses at both the factor level and the subfactor level. This comprehensive approach ensures a thorough evaluation of each element's relative importance.

4. Socio-Demographic Characteristics

The analysis of socio-demographic data and responses of participants about the factors influencing them towards public bus transportation is detailed below.

Table 2: Statistical distribution of various factors

FACTORS	PERCENTAGE
15-25	40
26-40	46
41-60	13
>61	1
Male	47
Female	53
Professionals	29
Govt. Employees	13
Private Employees	9
Students	33
Others	16

The Table 2 shows the statistical distribution of the samples collected during questionnaire survey. The socio demographic characteristics collected through questionnaire included the data related to their age, gender, occupation and the factors related to the usage of public transportation. It shows that the majority of respondents taking part in survey falls in the age group of 26-40 (46%). Gender distribution of the participated respondents is shows that 53% respondents are female followed by 47% male category. Employment status provides majority of the respondents are students (33%) followed by professionals (29%).

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5. Result and Discussions

5.1 Weights Obtained for Tangible and Intangible Criteria

Table 3: Weights obtained for tangible and intangible factors

	CRITERIA	AVERAGE WEIGHTS
TANGIBLE FACTORS	Travel cost	0.197
	Travel time	0.198
	Frequency	0.272
	Reliability	0.334
INTANGIBLE FACTORS	Safety	0.123
	Comfort	0.221
	Customer service	0.307
	Transit station condition	0.346

The tangible criteria for commuters' public transport choices included in the survey were travel cost, travel time, frequency and reliability as detailed in Table 3. The AHP approach shows that reliability is 1.22 times more preferred than frequency of bus. Among tangible factors, reliability (33.40%) is most preferred. Travel cost and travel time are perceived as equal weight by the users. The Table 3 shows the weights obtained by each factor. The intangible criteria for commuters' public transport choices included in the survey were safety, comfort, customer service and transit station condition as detailed in Table 3. Transit station condition is 1.12 times of customer service, 1.56 times of comfort and 2.80% of safety. Transit station condition (34.67%) is more preferred among intangible factors. Comfort and safety were least preferred factors as per the survey.

5.2 Weights for sub-criteria for selecting public transport options (tangible factors) Table 4: Weights for sub-criteria (tangible factors)

CRITERIA	SUB-CRITERIA	LOCAL WEIGHTS	GLOBAL WEIGHTS	PERCENTAGE
Travel cost	Ticket cost	0.450	0.088	45
	Parking fee	0.550	0.108	55
Travel time	Duration of journey	0.510	0.100	51
	Waiting time	0.490	0.097	49
Frequency	Day service of bus	0.350	0.095	35
	Availability of bus during early & late time	0.650	0176	65
Reliability	Adherence to schedule	0.480	0.160	48
	Reduction in frequency of breakdowns	0.520	0.173	52

When selecting public transport options, tangible factors play a crucial role. These tangible factors are often broken down into sub-criteria, each carrying its own weight or importance in the decision-making process. The amount of importance of ticket cost compared to parking fee is sought. It is found out that passengers

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give more importance to parking fee (55%) than ticket cost (45%). In case of tangible factors, the local weight of availability of bus during early and late time is of more concern, which is followed by reduction in breakdowns. The local weight is 0.650 for this factor and global weight is obtained by combining the local weight and weight of main criteria factor frequency, ie, 0.176.

5.3 Weights for sub-criteria for selecting public transport options (Intangible factors) When selecting public transport options, such as buses, there are various intangible factors to consider beyond just cost or convenience.

Table 5: Weights for sub-criteria (intangible factors)

CRITERIA	SUB-CRITERIA	LOCAL WEIGHTS	GLOBAL WEIGHTS	PERCENTAGE
Safety	Safety from accident	0.393	0.048	39
	Personal safety	0.606	0.074	61
Comfort	Crowdness	0.252	0.055	25
	Cleanliness of bus	0.199	0.044	20
	Availability of seat	0.316	0.070	32
	Smooth drive	0.231	0.051	23
Customer service	Behavior of bus operators	0.328	0.101	33
	Services provided by bus operators	0.671	0.206	67
Transit station condition	Safety at station	0.210	0.073	21
	Shelter from weather	0.324	0.112	32
	Amenities at station	0.465	0.161	47

5.4 Ranking of AHP

Rank the criteria's based on their relative weights obtained. The criteria with the highest weight are considered the best choice. Table 6 shows the result of AHP.

Table 6: Ranking of factors

Factors	Ranking
Main criteria level of tangible factors	
Reliability	1
Frequency	2
Travel time	3
Travel cost	4
Main criteria level of intangible factors	
Transit station condition	1
Customer service	2
Comfort	3
Safety	4

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6. Conclusions

This project deals with the public bus transportation system. The benefits of using bus transportation are highlighted. Firstly, the factors influencing individuals towards public transportation is found out through various literatures. Then the most preferred factors among different levels of classification of factors is determined by employing a structured multicriteria decision-making method. Analytical Hierarchy Process (AHP) is one type of multicriteria decision-making method used here. The factors are ranked in ascending order. Various factors influencing individuals towards public bus transportation is found out from literatures. The factors are safety, comfort, travel time, travel cost, transit station conditions, behaviour of bus operators, services provided by them, cleanliness, availability of seats, smooth driving, frequency, reliability, availability of bus during day times, availability during early morning and late night and absence of crowdness in bus. From these, factors are categorized into tangible and intangible factors. In AHP method, each factor is categorized under main criteria, so we obtained three levels as objective, main-criteria and sub-criteria. From AHP analysis, Reliability of bus is found to be the most preferred factor among other tangible factors by 33.40%. Reliability is followed by frequency, travel time and travel cost in case of tangible factors. The AHP approach shows that reliability is 1.22 times more preferred than frequency of bus. And it is 1.68 times more than travel time, 1.69 times more than travel cost. Among various intangible factors, transit station condition is more preferred than customer service, comfort and safety. Also transit station condition is 1.12 times of customer service, 1.56 times of comfort and 2.80% of safety. The elements at each level are compared in pairs to determine the relative importance of one criterion or sub-criterion over another. Under tangible factors, the sub-criteria, availability of bus during early and late time is more preferred (17.68%) followed by non-frequency of breakdowns (17.36%), adherence to schedule (16.03%), parking fee (10.83%), duration of journey (10.09%), waiting time (9.70%), day service of bus (9.52%) and ticket cost (8.86%). In case of intangible factors, the sub-criteria amenities at transit station (16.12%) is of high concern followed by shelter from weather in stations (11.24%), personal safety (7.49%), safety at station (7.30%), availability of seat (7.01%), absence of crowdness (5.58%), smooth drive (5.12%), safety from accident (4.87%), cleanliness of bus (4.42%), services provided by bus operators (2.06%) and behaviour of bus operators (1.01%). 26-40 age group of people (46%) is more participated in the survey. Female respondents (53%) are more than male category (47%).

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