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Assessment of Transit Transfer Experience: Case of Bangalore

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Abstract

Seamless transfers are key points to a successful public transport system. This paper tries to evaluate the role of transfers in public transit by analysing the users experience at transfer stations. Three different transfer levels in Bangalore are studied and concluded that transfer experience varies with passenger groups and transfer levels. Furthermore, the factors that will encourage non-transfer users to prefer transfer are also highlighted. This paper aims the public transit agencies to assess the needs of users' while transferring and hence to increase public transport patronization.

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Keywords: Transfers; Public transport; Users' Perception

1. Introduction

Urban transport plays an important role in the cities; it involves movement of people. The aim of public transit is to support this movement, but it is unable to provide door-to-door service which a personal mode could provide. The concept of "integration" is applied in public transport systems to make it an effective alternative to personal vehicles and hence to provide a "single journey experience" to its users.

Transfers are considered as a necessary evil. (Guo, 2008). Operators are forced to provide transfers while passengers dislike changing modes/services (Francisca Javiera Navarrete n, 2013). Passengers consider the time outside vehicle as more onerous than the travel time. Despite the importance of transfers in choosing public transit as

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a mode of travel, the number of studies related to transfers is limited (Mark Wardman, 2001). In India, there is a need to study the transfers in light of having NUTP aiming at Integrated Public Transport.

Two important aspects of integration are physical and fare integration. Physical integration is seamless and easy movement of passengers between services and fare integration removes the additional fare payment while changing the services. Thus, at a transfer node both physical and fare integration play a role.

The objective of this research is to evaluate the role of transfers in public transit by answering following research questions:

- What are the factors that will encourage transfer behavior?
- How transfer experience varies for passenger groups and transfer levels?
- What are the needs of non-transfer users to make transfer process easy for them?

1.1. Transfers

Transfers are locations where passengers change from one mode/service to other. A properly integrated and planned transfer hub will decrease the passengers travel time to an extent. Transfers can vary from a small stop along the road side to a station or an airport. Different authors have defined levels of transfers. A definition which can be adapted to the Indian context is as follows (Zhenbao Wang, 2012):

- Transfer stations: place where multiple bus routes intersect and hence provides a transfer opportunity between bus services
- Transfer centers: transfer point between different modes in an urban area. May include high capacity transit modes like BRT, MRT lines and buses
- Intermodal Terminals: transfer between several modes including regional modes like commuter rail, intercity buses with urban public transit modes like BRT, MRT and buses.

1.2. Components of Transfers

For a public transport trip, the components are in-vehicle time, out-of-vehicle time and walk times (Figure 1). The components of transfer affect the out of vehicle time which will affect the PT ridership. The components of transfer are:

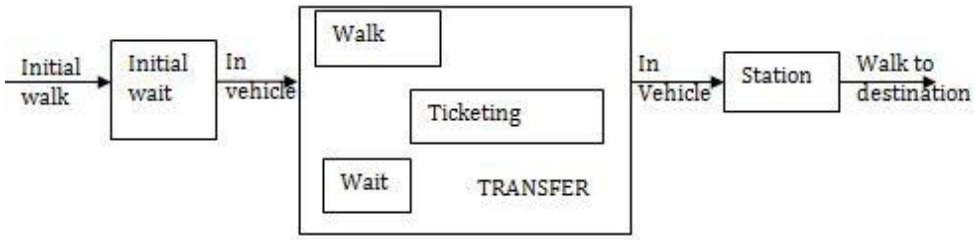

Fig. 1 Components of Trip

- Transfer Walk Time-Time between the moment the person alights from first service to the moment the person starts awaiting the next service (Francisca Javiera Navarrete n, 2013).
- Transfer Ticketing Time-Time taken by the passenger to take the ticket for next service if not fare integrated.
- Transfer Wait Time-Time elapsed between the moment a passenger arrives at a station/platform to the moment the passenger is able to board the next service (Francisca Javiera Navarrete n, 2013).

In addition, there will be a perceived walking and waiting time which is the extra component of time that the passenger perceives during walk and wait.

1.3. Factors Affecting Transfer Behavior

The factors affecting transfer behavior are grouped into trip factors, personal factors, station factors and service factors (Table 1)

Table 1 Factors affecting transfer experience

Factor Type	**Factors Affecting Transfer Experience**
Trip Factors	-Type of trip -Purpose of trip -No of transfers required in total trip -Trip time -Mode of the trip -Destination Land use
Personal factors	-Age -Gender -Employment -Wage rate -Household Size -Vehicle ownership -Driving license holder -Familiarity of facility -Ticket type
Station factors	-Station type -Walking distance -No of platforms -Information availability -Ease of finding directions -Associated infrastructure -Availability of escalators -Safety and comfort - Land use of surrounding area - Availability of Signboards - Rush in the station
Service factors	-Headways -Reliability -Schedule -Fare Structure -Route structure -Time table availability

*Compiled from-
- Assessment of transfer penalty for transit trips in Downtown Boston, Zhan Guo, MIT
- Thinking outside the bus, understanding user perceptions of waiting and transferring in order to increase transit use, Brian D. Taylor, Hiroyuki Iseki
-Transport and Path Choice in Urban Public Transport Systems, Zhan Guo, MIT
-Evaluating transit stops and stations from the perspective of transit users, Hiroyuki Iseki
-Interchange and Travel Choice Vol 1, Mark Wardman, Scottish Executive Central Research Unit

2. Methodology

In order to assess the transfer experience of users at a transfer location, customer satisfaction analysis method has been used in this research. It has utilized three sub Methods-Importance-satisfaction analysis, Factor Analysis and Structural Equation Modelling (SEM).

Importance Satisfaction Analysis (IS) is a tool to evaluate the relative priority that should be placed on different variables. Factor analysis is a data reduction tool and removes the duplication from a set of variables. SEM can help in identifying the influence of each variable on customer satisfaction. This process would help to identify the major factors contributing to transfer experience and analyze the relative significance of each factor on transfer experience.

2.1. Designing the Attributes and Variables

California Department of Transport for evaluating transit stops has adopted access, connection and reliability, information, amenities, safety and security as attributes (Hiroyuki Iseki, 2007). For this research, attributes more adaptable to Indian situation are used and are station/facility design, service and reliability, fare collection systems and structure, information availability, amenities, safety and security Their corresponding variables are listed in Table 2 which were finalized after conducting a pilot study.

2.2. Transfer and Non-Transfer User Survey

The transfer user survey will capture the importance and satisfaction of the variables (Table 2) on two different scales. The survey questionnaire included the following:

- User characteristics
- Importance of the variable on a scale of 1-5
- Satisfaction of the passenger on that particular variable on a scale of 1-5

Importance scale ranged from 1 to 5 with 1 being “not important at all” to 5 being “very important”. Passengers were asked to respond to the question "how important the variable is to the passenger”. Satisfaction of the transfer passengers was captured in the scale 1 to 5 ranging from “strongly disagree” to “strongly agree”. The passengers responded to the question “do you agree for this particular transfer station/stop?” Passengers were asked to fill in the self-administered sentences regarding the transfer experience at the station.

Public transport users who are not changing services/modes during their trip are known as non-transfer users. In order to identify the variation in needs of transfer and non-transfer passengers, a primary survey was carried out. The aim of the survey was to identify what are the factors that will encourage the passengers to use transfer based services in the city.

Public transport users are targeted in the survey. The passengers are asked to rank in a scale of 1-5, how likely they will change services if the facilities are provided in transfer stations? The scale is: most likely, likely, neutral, less likely and least likely. The users were asked to rank the identified variables in Table 2.

Table 2 Attributes and Variables selected for the study

Attributes	Code	Variables
1. Facility Design	FD1	Short distance to walk between services
	FD2	Easy to walk
	FD3	Adequate lighting facilities
	FD4	Easy to reach station
	FD5	Adequate stairs/escalators
2. Service & Reliability	SR1	Less time to wait for next service
	SR2	Bus/train/metro is on time

3. Fare Collection	FC1	Less money to be paid for transferring
	FC2	Less time to take ticket
4. Information	I 1	Signboards and maps are available
	I 2	Helpdesks area available
	I 3	Information on routes and services are available
5. Amenities	A 1	Adequate waiting areas (seating)
	A 2	Comfortable environment
	A 3	Clean station/stop
	A 4	Amenities are available
	A 5	Easy access to amenities
6. Safety &Security	SS1	Safety during day and night
	SS2	Presence of security guards

3. Case Study- Bangalore

Bangalore is one of the eleven metropolitan cities in India with a public transit ridership of 45% (Bangalore Mobility Indicators, 2008). The city has regional services operated by Indian railway and bus service by KSRTC and urban bus services by BMTC and metro services by BMRCL.

For the research, three case stations are selected, one for each level of transfer facility (Table 3).

Table 3 Transfer Stations selected for the study

Transfer level	Name of station	Interchanging modes
Intermodal Terminal	Majestic Interchange zone	Rail-Bus, Bus-Bus
Transit Centre	Mantri Square Interchange zone	Bus-Bus, Metro-Bus
Transit Station	Yeshwantpur Bus Station	Bus-Bus

Majestic is one of the major Intermodal Terminal in Bangalore. It is an interchange zone with Bangalore city railway station, KSRTC bus stand, BMTC bus terminal and metro station. The Table 4 shows the transfer time for passengers at Majestic interchange zone.

Table 4 Transfer Time - Majestic

Transfer movement	Walking time (min)	Waiting time (min)
Train-Bus	10-15	5-60
KSRTC-BMTC	4-10	5-60
BMTC-BMTC	1-5	5-60

Mantri Square bus stop is located along the road side. There are two bus stops in the area and the passengers transfer from one to next, as well in the same bus stop. Mantri Square Sampaige road metro station is the metro station in the operating line. It is located about 200 m away from the bus stop. Apart from few seating spaces, the bus stop does not have many facilities. For transfer between metro and bus, users cross the road. The transfer time at this station is shown in the Table 5.

Table 5 Transfer Time- Mantri

Transfer movement	Walking time (min)	Waiting time (min)
Metro-Bus	5-8	2-60
BMTC-BMTC	0-3	2-60

Yeshwantpur bus station is a transit center in the Bangalore city with major bus to bus transfers. Yeshwantpur station has 2 floors for bus transfers. The 2 floors are connected by stairs and lifts. The average walking time at Yeshwantpur is about 1-3 minutes and waiting time is about 5-30 minutes.

a b c

Fig. 2 (a) Majestic Bus Station; (b) Mantri Square Bus Stop; (c) Yeshwantpur Bus Station

4. Data Collection

A pre survey study was done to understand the movement of passengers at these transfer stations during transfer. The passengers were captured while waiting for the next service after alighting from the first service. The passengers' intention to transfer is identified prior to the survey. The number of samples collected at each station is given in Table 6.

Table 6 Samples Collected

Transfer Level	Name of the station	No of samples	Percentage
Intermodal Terminal	Majestic	90	35%
Transit Station	Yeshwantpur	75	30%
Transit Center	Mantri Square	92	35%

5. Analysis and Findings

The analysis was done for three stations and for each station analysis was carried out for different passenger groups based on gender, frequency and age to identify the variation in their transfer experience and satisfaction.

5.1. Transfer Users- Majestic Interchange Zone

IS analysis was conducted initially to find out the difference in user perception prior to factor analysis and structural equation modeling. According to IS analysis,

- 1st quadrant: Most Important and satisfied
- 2nd quadrant: Most Important but not satisfied.
- 3rd quadrant: Less Important and satisfied
- 4th quadrant: Less Important and not satisfied

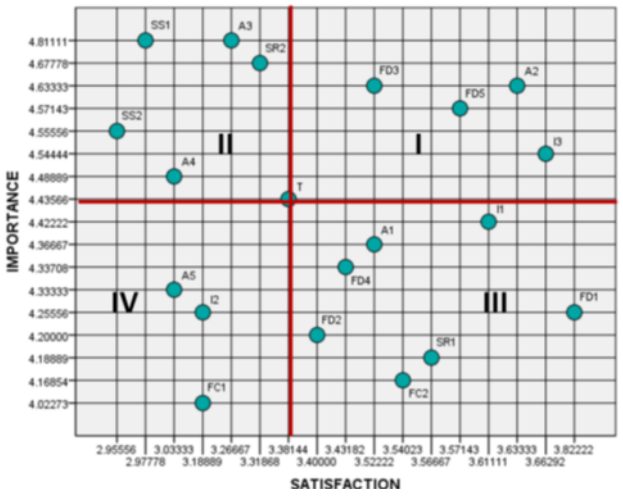

Fig. 3 Cartesian Diagram- Majestic

- FD3- Lighting facilities, FD5- Adequate stairs, A2-Comfortable environment and I3-Information on routes and services lie in 1st quadrant and are important and passengers are satisfied with these. (Fig.3)
- SS1-Safety during day and night, SS2- Presence of security guards, A3- Cleanliness of the station, A4- Availability of amenities and SR2- Timely arrival of bus/train/metro lie in the 2nd quadrant and are the variables which need immediate attention. (Fig.3)
- SR1- Less time to wait for next services, FC2- Less time to take ticket, A1- Adequate waiting areas, FD2- Easiness to walk, FD4- Easiness to reach station, I1- Signboards and maps, FD1- Short distance to walk between services are less important compared to others, and passengers are satisfied with these variables (Fig.3).
- FC1- Less money to be paid for transferring, A5- Easy access to amenities and I2-presence of helpdesks lie in 4th quadrant. Users' are not satisfied with these variables and they are less important also.

The IS analysis depicts that the passengers are less worried about walk time (5min) and wait time (5-60 min) and they need more safe and secure waiting areas and better amenities and a reliable public transport service.

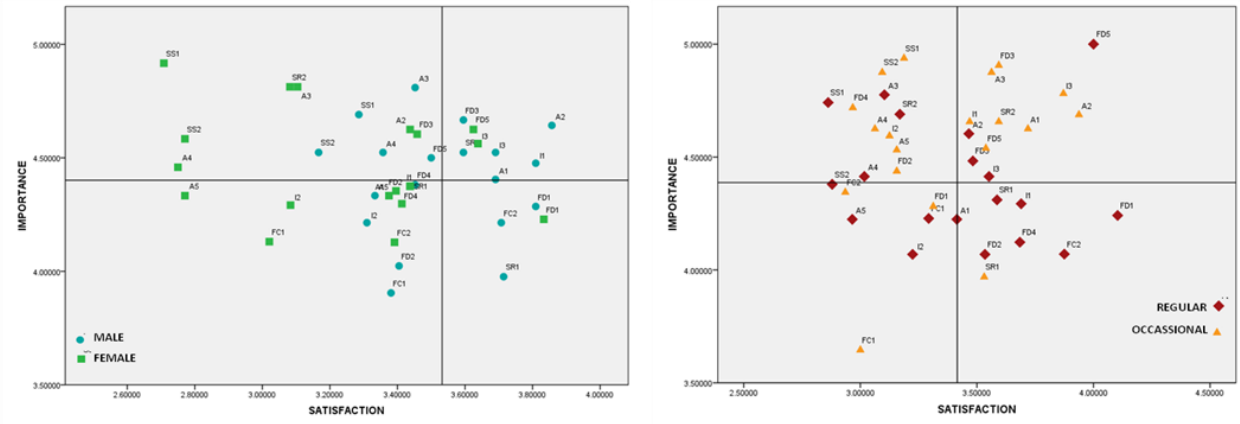

Fig. 4 Target group analysis- Majestic

The Cartesian diagram (Fig. 4) based on gender shows female passengers are more dissatisfied for the variables: safety and security (SS), amenities (A), service reliability (SR) and comfortable environment (A2) than males who are more dissatisfied for facility design (FD) variables.

Cartesian diagram based (Fig. 4) on frequency depicts that the regular users gave more importance to safety (SS), amenities (A) and service reliability (SR), occasional users expressed the need for information systems (I) and facility design variables (FD) like easiness to walk, short distance etc.

5.1.2. Factor Analysis and Structural Equation Modelling

In this study, factor analysis was used as a potential tool to identify the components affecting the transfer experience of passengers. The factor analysis was done in following steps (for Majestic):

The number of components was determined based on the Scree plot. Those components with Eigen values greater than 1 are considered. As explained in the Table 7, the transfer experience can be explained using 1st 5 components. In total 69.51% of the variation can be explained by 1st 5 components. (Table 7)

Table 7 Variance explained

Component	**Initial Eigenvalues**			**Extraction Sums of Squared Loadings**			**Rotation Sums of Squared Loadings**		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	6.498	34.199	34.199	6.498	34.199	34.199	4.431	23.322	23.322
2	2.849	14.996	49.195	2.849	14.996	49.195	2.689	14.154	37.476
3	1.597	8.407	57.602	1.597	8.407	57.602	2.590	13.632	51.108
4	1.179	6.207	63.809	1.179	6.207	63.809	1.975	10.395	61.503
5	1.084	5.705	69.514	1.084	5.705	69.514	1.522	8.011	69.514
6	.872	4.589	74.103						
7	.730	3.843	77.945						
8	.627	3.302	81.247						
9	.558	2.936	84.183						
10	.493	2.593	86.776						
11	.451	2.375	89.150						
12	.423	2.228	91.378						
13	.353	1.856	93.234						
14	.305	1.606	94.839						
15	.277	1.458	96.298						
16	.225	1.186	97.484						
17	.204	1.074	98.558						
18	.149	.783	99.342						
19	.125	.658	100.000						

Varimax rotation was performed to obtain the rotated factor loadings. In order to determine which variables are related to the respective components, loadings greater than 0.5 is considered. The output of this step is shown in Table 8.

Table 8 Rotated component matrix

Variables	**Component**				
	1	2	3	4	5

FD1- Short distance to walk between services	-.095	**.780**	.033	.034	.228
FD2- Easiness to walk	.017	**.676**	.363	.192	.161
FD3 – Lighting facilities at station	.516	**.571**	.200	.217	-.250
FD4 –Easiness to reach station	.257	**.764**	-.021	-.032	-.007
SR1 –Less time to wait	.051	.116	.135	**.867**	.056
SR2 –Timely arrival of bus	.264	-.099	.086	**.742**	-.145
FC1 – Less money to be paid	.106	.165	.261	**.541**	.465
FC2 –Less time to take ticket	.078	.191	.008	.013	**.785**
I1 –Availability of signboards and maps	.096	.277	**.758**	.069	.208
I2 –Presence of help desks	.422	-.011	**.638**	.183	.061
I3 –Availability of information on routes/services	.377	.103	**.726**	.116	-.157
A1 –Adequate waiting areas	.494	-.037	**.698**	.144	-.020
A2 –Comfortable environment	**.640**	.001	.323	.146	-.124
A3 –Cleanliness	**.762**	.052	.160	.147	-.140
A4 –Availability of amenities	**.787**	-.151	.197	.203	.244
A5 –Access to amenities	**.701**	-.093	.300	.182	.272
SS1 –Safety during day and night	**.834**	.287	.059	.005	.015
SS2 –Security facilities	**.780**	.148	.254	-.031	.048
FD5 –Adequate vertical circulation elements	.146	**-.633**	-.002	.321	-.531

Component 1 is heavily loaded with the amenities variables (A) and safety and security (SS). Component 2 with facility design variables, component 3, 4 and 5 are heavily loaded with Information variables, Integration variables and ticketing time respectively. Based on the results of factor analysis, each component is named as shown in the Table 9 based on loaded variables.

Table 9 Components

Component 1: Feeling of comfort and safety	Comfortable environment
	Cleanliness of the station
	Amenities
	Access to amenities
	Safety during day and night
	Security facilities
Component 2: Transfer facility design	Short distance to walk between services
	Easiness to walk
	Lighting facilities at the station
	Easiness to reach the station
	Vertical circulation elements
Component 3: Information and waiting	Availability of sign boards and maps
	Presence of help desks
	Information on routes and services
	Adequate waiting areas
Component 4: Integration	Less time to wait for next service
	Timely arrival of bus/train
	Less money to be paid for transferring
Component 5: Ticketing time	Less time to take ticket

SEM was used to determine the significance of these components on the overall transfer experience. The structural equation modeling is done using SPSS AMOS software. The regression scores of components are used as input for SEM.

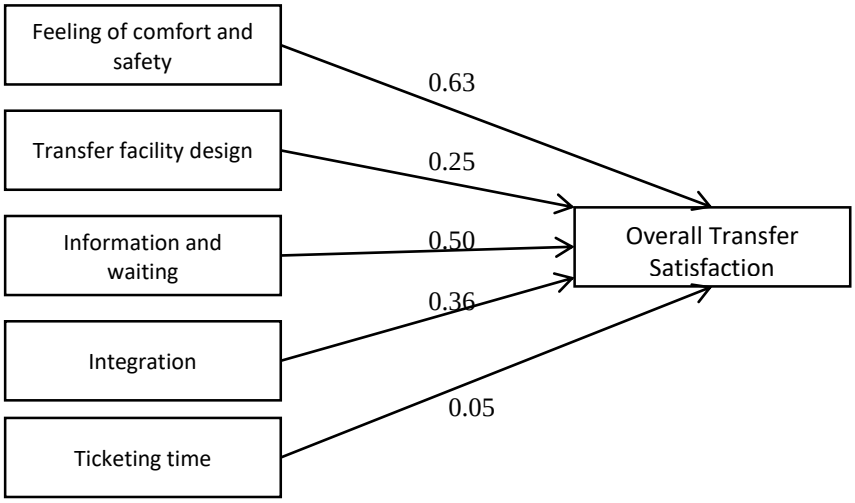

Fig. 5 SEM Regression Coefficients- Majestic

The fitted model has R^2 value of 0.84 with RMESA p value as 1 confirming a good fit of the model. On the basis of regression weights (Fig. 5), it is evident that feeling of comfort and safety, information and waiting, integration and transfer facility design influence the transfer satisfaction. It is interesting to note that ticketing time has less influence on satisfaction whereas comfort and safety has highest influence, even more than facility design and integration of services.

These steps of IS analysis, factor analysis and SEM are repeated for all transfer stations and for all passenger groups. The results after SEM (regression coefficients) are given in Table 10.

Table 10 SEM Regression Coefficients- All Stations

Component	**Majestic Interchange zone**					**Yeshwantpur**			**Mantri Square –Bus & Metro station**				
	Total	Gender		Frequency		Total	Gender		Total	Gender		Frequency	
		M	F	R	O		M	F		M	F	R	O
Comfort	0.63	0.36	0.65	0.69	0.47	0.54	0.24	0.37	0.67	0.24	0.62	0.54	0.55
Safety	0.63	0.36	0.65	0.69	--	0.54	--	0.54	0.67	0.61	0.47	0.54	0.64
Amenities	--	--	--	0.69	0.53	--	--	0.54	0.60	0.51	0.47	0.38	--
Service Integration	0.36	0.28	0.41	0.43	0.25	0.49	0.41	0.46	0.60	0.51	0.47	0.48	--
Fare Integration	--	--	--	--	--	0.24	0.3	--	0.17	--	--	--	--
Information	0.50	0.64	0.54	--	0.5	0.49	0.41	0.28	0.60	0.38	0.47	0.48	0.28
Waiting	0.50	0.64	0.54	--	--	0.41	--	--	0.67	0.61	0.62	0.54	0.55
Facility design and access to station	0.25	0.34	0.03	0.34	0.1	0.41	0.55	0.54	0.24	0.24	0.21	0.24	--

(M: Male, F: Female, R: Regular, O: Occasional)

- Safety and comfort is more significantly influencing the female passengers compared to male users. It should be noted that the safety and comfort is 20 times more significant than facility design variables for female users.
- The significance of amenities is high in the Mantri Square, as the interchange zone does not have amenities apart from very few waiting areas.

- Service Integration is significant for all stations, but the significance increases as transfer level decreases. It is evident from the SEM coefficients that service integration is more significantly influencing the transfer experience of female users.
- Significance of information is high for intermodal terminal KBS and transit station- Mantri Square. Majestic being an intermodal terminal and one of the main stations in the city, information systems are significant for passengers transfer choice. The SEM regression coefficient is high for occasional/new users as the need of information systems is more for these users. Information and waiting are more significant for male users than the safety and comfort at the station.
- The SEM regression coefficient for waiting area is high for Mantri Square bus stop because the stop has very few waiting areas when compared to the number of passengers using that particular stop.
- In case of Yeshwantpur station, the regression coefficient for facility design is high. The reason can be location of the bus station the passengers have to cross busy roads and flyover to reach the bus station.

5.2. Non- Transfer Users

The main aim of non-transfer user survey is to identify the factors which will encourage public transport passengers to use transfer facilities. The percentage of passengers who had given maximum rating i.e most likely is used as a tool to measure the most important factor (Table 11)

Table 11 Non-Transfer User Survey Analysis

Variable	Percentage
If you get next service (bus) in the same platform	30%
If it is easy to walk between the platforms/stops	7.7%
If it is easy to reach the platform/stop	15.4%
If you get next service (bus) within 1 minute	69.3%
If you can know the time of arrival of next service (bus)	34.6%
If the next service (bus) arrives on time	42.3%
If you dont have to pay for changing services	34.6%
If there are enough signboards and maps	23.07%
If there are adequate help desks for help	19.2%
If it is easy for you to get information on bus routes	26.9%
If there are adequate waiting areas for you to wait	19.2%
If it is comfortable for you to wait	26.9%
If the platform/stop/station is clean	30.7%
If there are adequate amenities available	15.3%
If it is easy to access these amenities	19.2%
If you feel safe and secure during day and night at station	42.3%
If there are adequate security facilities at the station	34.6%
If the station is well lit	15.3%
If there are adequate vertical movement elements like stairs, escalators	30.7%

The main factors that will encourage the transfer choice seems to be

- Next service available within 1 minute 2. Next service arrives on time
- If the user feels safe and secure at the transfer station.
- If the user does not have to pay for transferring

It should be noted that the first three needs are similar to transfer users. The non-transfer passengers have highlighted the importance of fare integration.

6. Conclusion and Recommendations

The study has evaluated the transfer experience of users and transfer needs of non-users and has arrived at the conclusion that it varies with passenger groups and transfer levels. First, comfortable, adequate and clean environment and waiting areas are necessary requirements for all levels of transfer stations. Service integration is required while planning for the operations to ensure that users prefer transfer process. The study also observed that service integration can bring higher transfer satisfaction to female users. It is also important to design a safe and comfortable environment at the transfer station, which affects the satisfaction of female users significantly. Availability of information also needs to be ensured while designing the transfer facilities to attract more occasional users. Hence, the research has helped to determine the factors to be considered while planning and designing a transfer station along with its significance and the need for further researches on this topic.

Intermodal terminal, transit station and transit centers namely Majestic, Mantri Square and Yeshwantpur in Bangalore are analyzed in the study. Passengers at Yeshwantpur transfer station (interchange in a building) are more satisfied than other two interchange zones, Majestic and Mantri.

- Safety and security needs immediate attention for all passenger groups at the three transfer stations. Users have mentioned the need of comfortable, clean and safe waiting areas at the transfer stations. It is observed that female users are very much concerned about the safety and security during transfers. Information facilities are necessary for passengers to have a comfortable transfer.
- It is concluded that the significance of service integration is higher in transit centers and transit stations than the intermodal terminal which are multimodal transfers between regional and city services. And for transit center station, specifically at Mantri Square the integration of service is almost twice significant than a terminal station (Majestic).
- Apart from the above stated requirements, for regular users, integration of services and facility design are required which are twice and thrice significant respectively than occasional users. For occasional users, availability of adequate amenities and information hold some significance.
- For male users, facility design is more significant than females. Requirements of female users include integration of services, which is twice significant than males, in addition to other common requirements. Target group analysis based on the gender of users is able to conclude that for female users, safety and comfort are twice significant than for male users. These components are also 20 times more significant than facility design components for females. Facility design components are more important for male users and they are 10 times more significant than female users also. Study shows that integration of services is twice significant for female passengers than male users.

For non-transfer passengers, there is a need of service and fare integration. As it is concluded from the study that 70% of the users are ready to transfer if they get next service within 1 minute. 43% of them need their next service on time to prefer public transport transfer.

The three main recommendations based on above conclusions for Bangalore are:

- Comfortable, clean, safe environment and adequate waiting and access facilities at the transfer stations.
- Integration of services and maintaining the reliability of these services
- Adequate, accurate information on routes, services, platforms etc. at transfers.

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