A presentation on

Service Quality Assessment of Electric Buses: A PLS-SEM Approach

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CONTENT

CURRENT STATUS OF ELECTRIC PUBLIC TRANSPORT IN NEPAL

a. **Sajha Yatayat: 40 buses** come in operation
b. **Sundar Yatayat:** 4 operation in the Kathmandu valley
c. **Safe Tempo:** 714 running in Kathmandu Valley
d. **E-rickshaws:** 36,294 assembled for operations
e. **Long route electric buses**: > 40 microbuses in Kathmandu – Sindhuli route, Kohalpur-Surkhet route
f. **LMC Ward 3**: One free shuttle service running for local

- Nepal Electricity Authority is working for operating 51 charging stations throughout the country.
- Development of EV Charging Stations the Private Sector (around 70 locations)
- Government of Nepal announced following 2 additional initiatives in the fiscal policy through the annual budget speech on 29 May 2022.
    a. No fossil fuel vehicles will be purchased in the coming fiscal year except electrical vehicle
    b. Budget provision for establishing additional 50 charging stations by the government.

INTRODUCTION

Public Bus

- The most common form of mass transit service provided throughout Nepal.
- Public buses are available for the general public and are mostly operated by local state and municipal government authorities.
- Convey a large number of people at the same time in an efficient, convenient, and affordable way.
- Public buses operated on fixed routes and schedules over the existing roadways.
- With the combination of sustainability, connectivity, and inclusivity, public buses (especially EV) have the capacity to hold the potential to reshape our cities and improve the lives of millions.

DEVEPLOPMENT OF PUBLIC BUS SERVICES IN KATHMANDU

September 1959

Nepal Transport Service starts local bus service between Kathmandu and Patan, marking the beginning of public transportation in Nepal.

December 1975

Electric trolley buses introduced along the 13 km route from Tripureshwor to Suryabinayak

2000

Following removal of diesel three wheelers, the number of Safa tempos were increased to 600 and micro buses were introduced.

November 2009

Trolleybus system formally closed end of an era of government direct role in public transportation service

October 1961

Sajha Yatayat starts services

1966

Nepal Transport Service, which owned 11 buses, closes its service.

1993

Seven Safa Tempos (electric three wheelers) introduced

2007

Sajha Yatayat stops its service

April 2013

Sajha Yatayat restarts its service with 16 buses

Source: CERN

Existing situation (2022)
Photo taken during study

CONVENTIONAL BUSES

EXISTING SCENARIO OF PUBLIC BUS SERVICES IN KATHMANDU

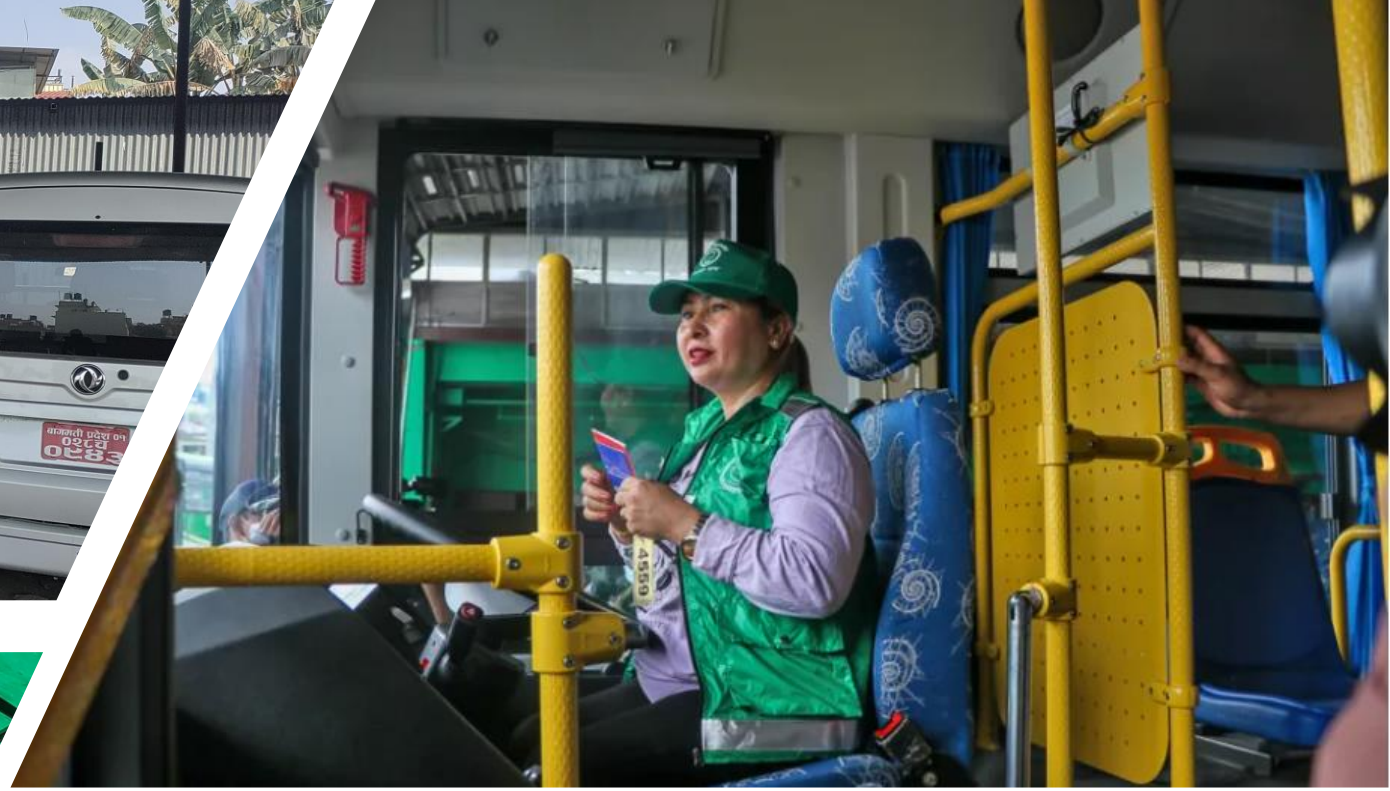
a

b

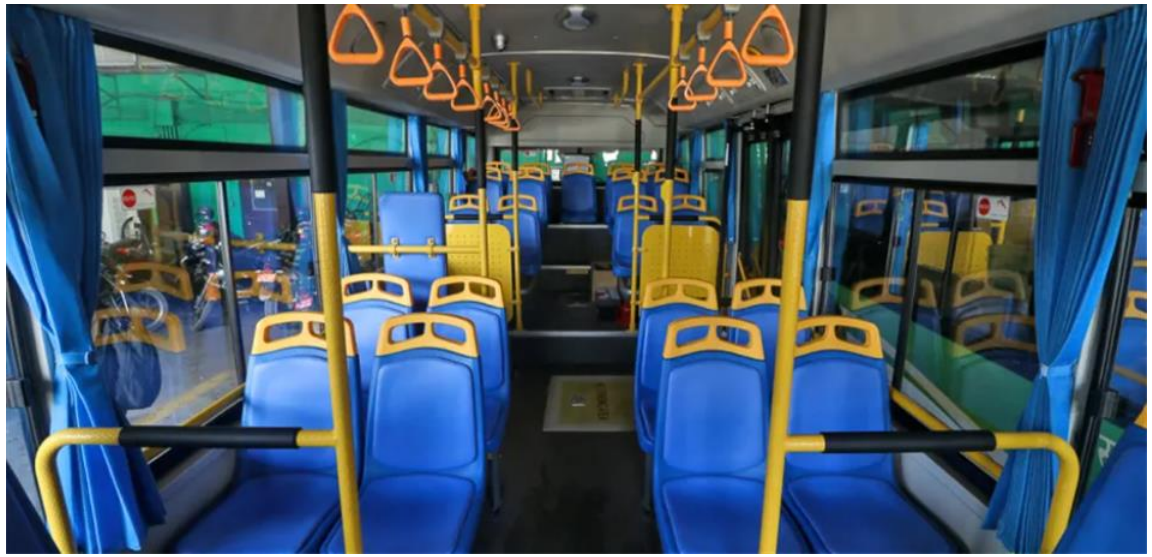
CONDITION OF PUBLIC BUSES IN KATHMANDU

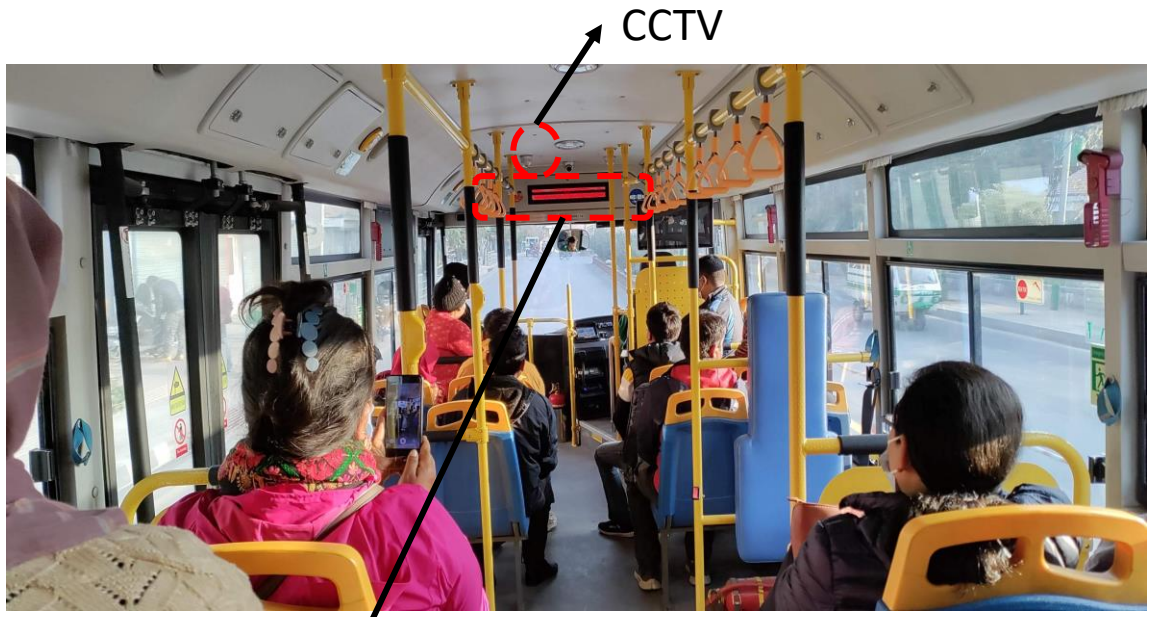
ELECTRIC BUSES

Electric bus and charging stations



ELECTRIC PUBLIC BUSES





NEED OF THE STUDY

Who are the users of public buses and what are their expectation.

What public bus organizers are lacking to provide to public bus users?

Which aspects of public bus service is most crucial and which is least important?

OBJECTIVES

- To determine and identify the fundamental attributes that affect service quality and latent constructs that the satisfaction of electric bus users
- To develop an SQ model and identify the impact of various attributes on riders' overall satisfaction.

Literature Review

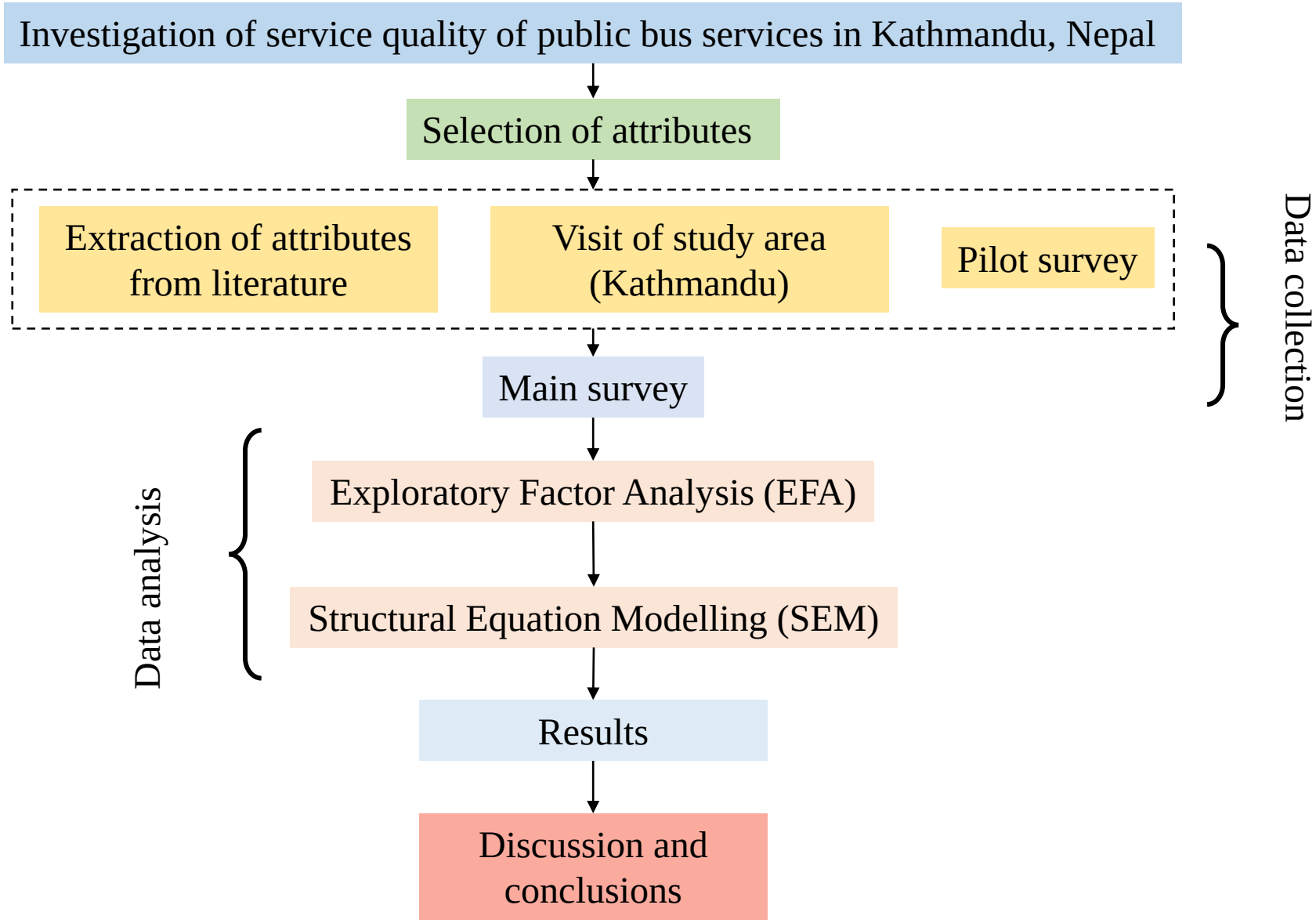
Literature Review

Study	Transit mode and context	Attributes Analyzed	Key Attributes	Statistics Method
Deb and Ali Ahmed, 2018	Service quality of bus in Agartala City, India	Sixteen attributes (Safety, Cleanliness, Comfortability, Overcrowding, Frequency, Fare, Speed, Journey time, Waiting time, Punctuality, Cleanliness, Information, Accessibility, Space, and Courtesy).	Safety, Comfort, Accessibility, and Timely performance	Linear regression and SEM
Islam et al., 2016	Bus service Dhaka city, Bangladesh	Sixteen attributes (Proximity from home, Structural condition, Service frequency, commuting periods (weekdays and weekends), Seat availability and Comfort, Accessibility, Proximity from workplace, Air ventilation, Female harassment, courtesy, Frequency, Cleanliness, Noise level, Route information).	Punctuality, Reliability, Service Frequency, Seat Availability, Commuting experience, Comfort, Structural condition.	Pattern Recognition Neural Network (PRNN), Generalized Regression Neural network (GRNN) and Probabilistic Neural Network (PNN)
Wong et al., 2017	Bus transit, Hongkong	Eight attributes (Ease of boarding and alighting, waiting time, Availability of seats, Attitude of drivers, Walking distance to bus stop, Condition of bus stop, Travel time and Temperature inside bus)	Seat availability, Condition of station, Driver's attitude, Ease of boarding and alighting,	Ordered logit model.

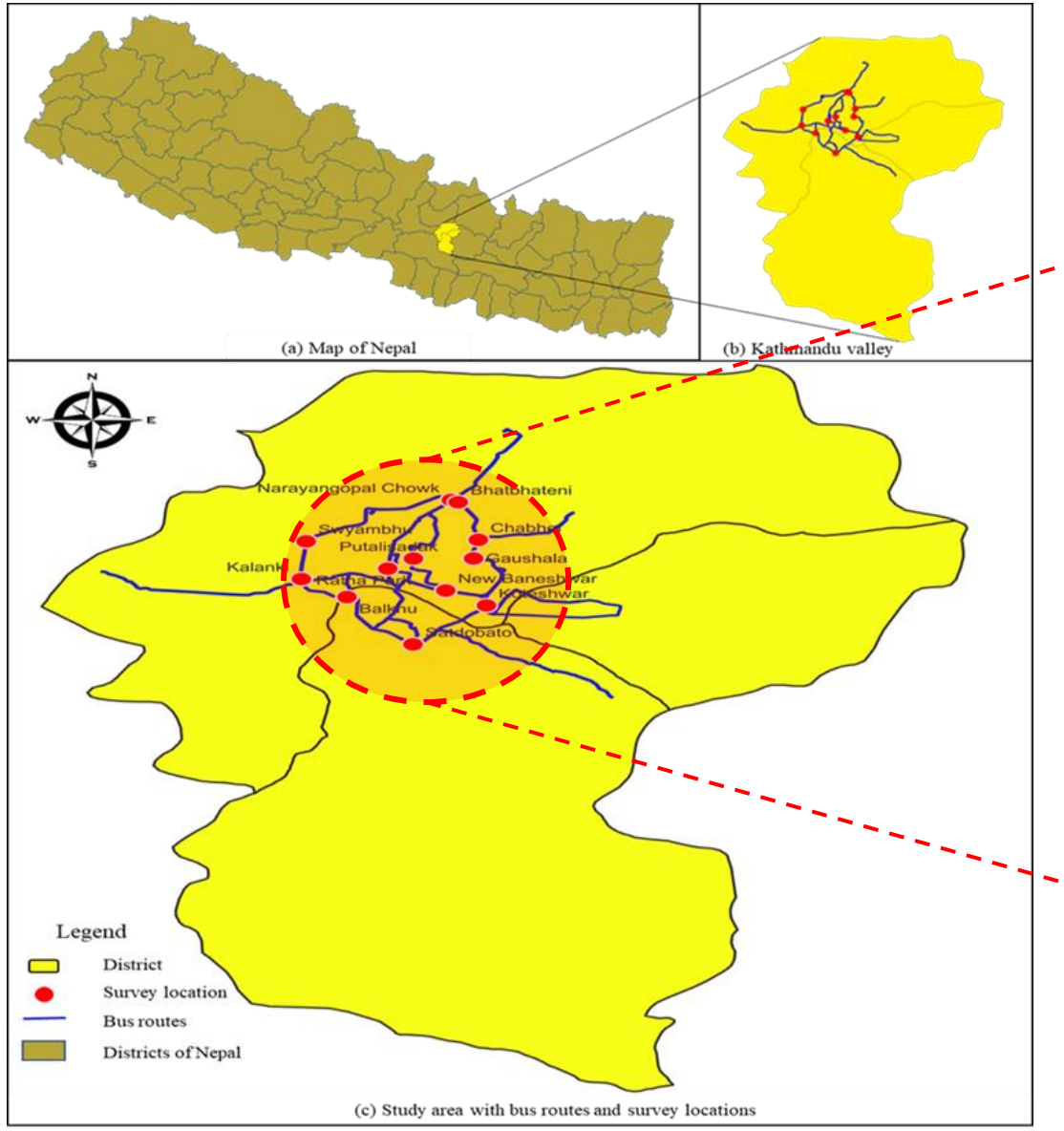
Literature Review

Study	Transit mode and context	Attributes Analysed	Key Attributes	Statistics Method
Del Castillo Benitez, 2012	Service quality of urban bus, Bilbao, Spain	Nine attributes (Frequency, Cleanliness, Punctuality, Prices, Travel time, Staff performance, Comfort, Information, and Safety).	Frequency, safety, comfort, cleanliness, and information	models based on averages; a model based on a multivariate discrete distribution and a generalized linear model
Morton et al., 2016	Bus Transit, Scotland	Nine attributes (Frequency, Punctuality, Reliability, Cleanliness, Availability, Comfort, Security, Information, and Accessibility).	Frequency, Security, Comfort, Reliability, and Cleanliness	SEM
Sam et al., 2018	Bus service quality in Kumasi	Nine attributes (Security, comfort, cleanliness, frequency, travel time, reliability, punctuality, waiting time, and network coverage).	Service reliability and responsiveness	SERVQUAL methodology

Methodology Flowchart



STUDY AREA



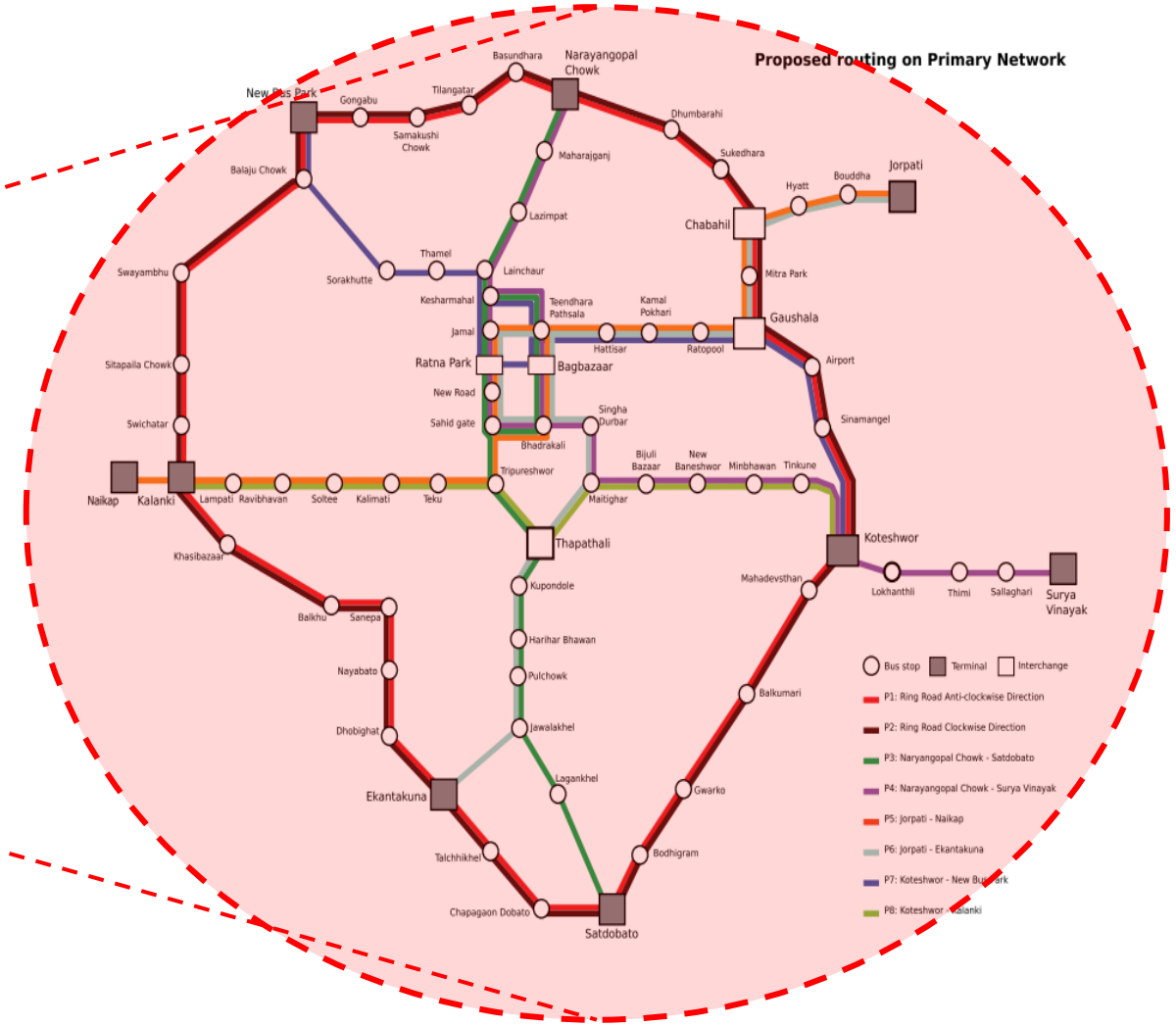


Figure : Study area map (a) Administrative boundary of Nepal, (b) Kathmandu valley area and (c) bus routes and survey locations within Kathmandu valley

Selection of Factor Affecting Service Quality

Table 1: Attributes of Service quality

Attributes of service quality	
Availability of the service	Frequency of service
	Network coverage (area)
Accessibility of the services	Ease of access to reach the bus stop (First mile and last mile connectivity)
	Availability of the walking infrastructure
Information	Availability of travel-related information at bus stops (about routes, time, fare, bus number and timing
	Real time information inside bus
	Information available at other communication technologies (App, Websites)
Time/ Reliability	Punctuality against time
	Regularity of service
	Passenger waiting time at bus stop
	Journey time inside bus
Comfort	Attitude of the driver/conductor
	Level of comfort inside bus (Seat availability, Spaces for standing, Availability of grab handle, crowding)
	Comfort while alighting and boarding the bus
	Cleanliness inside the bus
	Seat availability/ maintenance of seat at bus stop
	Conditions of the Bus
	Availability/ Maintenance of sheds at bus stop
Safety and Security	Security against crimes/ thefts during travel (availability of CCTVs/ Security personnel)
	Lighting inside bus
	Lighting at bus stop
	Sense of security to women against harassment (especially at nighttime)
Overall satisfaction	Overall satisfaction with bus service quality (Before evaluation)
	Overall satisfaction with bus service quality (After evaluation)

Table 2: Attributes of Personal attitude

Personal Attitude	
Perceived value	Considering the ticket price, I believe that bus transit offers sufficient services
	Considering the service provided, the ticket price is reasonable
Involvement	I feel that taking public transit is consistent with my lifestyle
	I always pay attention to the information about public transit
	I feel that taking public transit I help to protect the environment.
	I like others to know the fact that I take public transit.
	I like people who take public transit
Behavioral intention	I am willing to recommend the bus travel to others
	I am willing to keep on using the bus services in the future.

Table 3: 5-Point Likert scale table

Service quality rating (5-point Likert scale)				
1-Worst	2-Poor	3-Neutral	4-Good	5-Excellent
Personal attitude rating (5-point Likert scale)				
1–Strongly disagree	2-Disagree	3-Neutral	4-Agree	5-Strongly Agree
Overall Satisfaction rating (5-point Likert scale)				
1-Highly Dissatisfied	2-Dissatisfied	3-neutral	4-Satisfied	5-Highly Satisfied

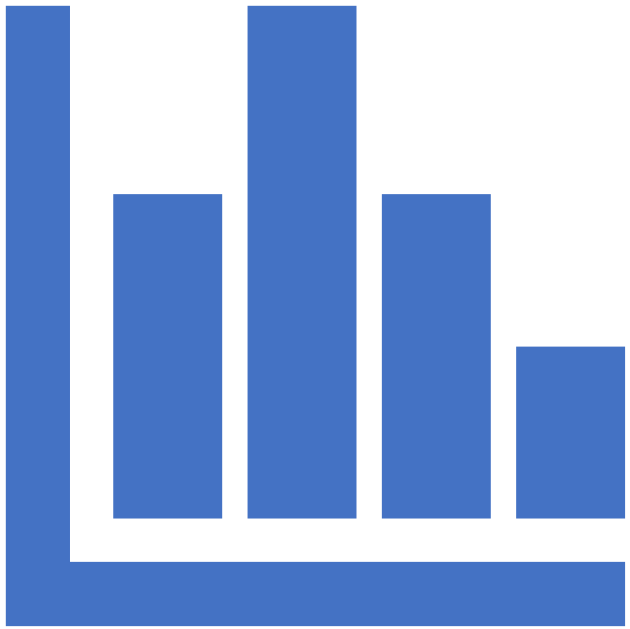
Estimation of Sample Size

- The sample size for the questionnaire was considered using the given equation (Krejcie and Morgan, 1970).

$$n = \frac{\chi^2(N).(P).(1-P)}{ME^2(N-1) + \chi^2(P).(1-P)}$$

Where, n = sample size of the survey, χ^2 = Chai square value at 95% confidence level =3.8342 for 1 degree of freedom, P = the population proportion = 0.5 as this will give maximum sample size, ME = the accuracy degree expressed as proportion, taken as 0.05, N = population or total ridership value.

- The population size is taken as 948,464 which is 27.6% of total ridership (Khokali, 2017)
- The sample size was obtained to be 384.
- Total of 388 responses for electric buses were used for analysis



DESCRIPTIVE ANALYSIS OF MAIN SURVEY

Socio-Demographic and trip Characteristics of Electric Buses

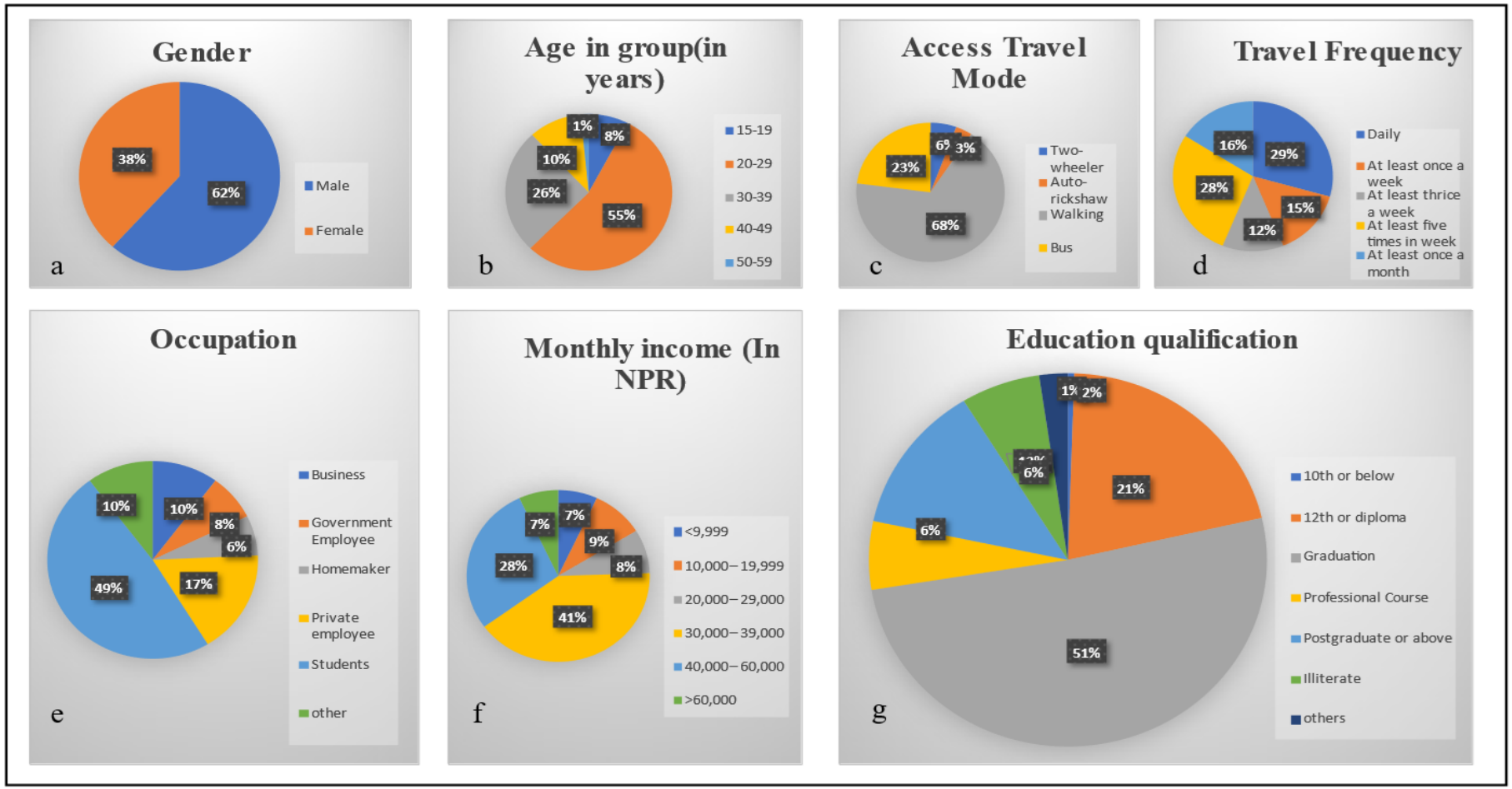


Figure: Socio-demographic and Trip characteristics: (a) Gender distribution, (b) Age in group distribution, (c) Access travel mode distribution, (d) Travel frequency distribution, (e) Occupation distribution, (f) Monthly income distribution (g) Education qualification

Table: Descriptive analysis of variables of service quality and personal attitude (Rating of satisfaction)

Variables	Notation	Min.	Max.	Mean	Std. Dev
Overall Satisfaction of electric bus service quality (Before Evaluation)	OS1	1	5	3.35	0.84
Frequency of the bus service available	SQ1	2	5	**2.73**	0.68
Network Coverage [Routes and connectivity of bus to all areas]	SQ2	2	5	3.34	0.69
Ease of access to reach bus stations from the trip origin [Availability of travel modes, i.e., Auto-rickshaws]	SQ3	1	4	3.06	0.67
Availability of walking infrastructure (like sidewalk, footpath)	SQ4	1	5	3.02	0.97
Availability of travel-related information at bus stops (about routes, timing, fare, and bus numbers)	SQ5	1	5	**2.16**	0.79
Real time information inside bus	SQ6	1	5	3.36	1.10
Information available at other communication technologies (Apps, websites)	SQ7	1	5	3.03	**1.38**
Punctuality against time	SQ8	1	5	3.19	0.82
Regularity of services	SQ9	1	5	**4.08**	0.80
Passenger waiting time at bus stop	SQ10	1	5	3.08	0.69
Journey time inside bus	SQ11	1	5	2.86	0.84
Attitude of driver/ conductor	SQ12	1	5	3.50	0.93
Level of comfort inside bus (Seat availability, spaces for standing, availability of grab handle)	SQ13	1	5	3.27	**1.04**
Comfort while alighting and boarding the bus	SQ14	1	5	**3.51**	0.93
Cleanliness inside bus	SQ15	1	5	**2.67**	0.89
Availability/ Maintenance of seats at bus stop	SQ16	1	5	3.50	**1.04**
Condition of the vehicles	SQ17	1	5	3.49	0.97
Availability/ Maintenance of sheds at bus stops	SQ18	1	4	**2.71**	0.70
Security against crimes/ theft during travel (availability of CCTVs/ security personnel)	SQ19	1	5	3.45	0.94
Lighting inside vehicles	SQ20	1	5	3.45	**1.24**
Lighting at bus stops	SQ21	1	5	3.19	0.96
Sense of security to women against harassment (especially at nighttime)	SQ22	1	5	**3.59**	1.03
Overall satisfaction of electric bus service quality (After evaluation)	OS2	1	5	3.51	0.8
Considering the ticket price, I believe that bus transit offers sufficient service.	P1	1	5	3.05	**0.97**
Considering the service provided, the ticket price is reasonable.	P2	1	5	3.35	0.92
I feel that taking public transit is consist with my lifestyle.	P3	1	5	3.40	0.83
I always pay attention to the information about public transit.	P4	1	5	3.61	0.77
I feel like taking public transit I help to protect the environment.	P5	1	5	4.07	**1.01**
I like others to know the fact that I take public transit.	P6	1	5	3.67	0.78
I like people who take public transit.	P7	1	5	3.77	0.75
I am willing to recommend the bus travel to others.	P8	1	5	3.57	0.73
I am willing to keep on using the bus services in future.	P9	1	5	3.58	0.84

Partial Least Squares Structural Equation Modeling (PLS-SEM)

- PLS-SEM is a versatile and powerful statistical tool for analysing complex interactions between variables frequently used in fields such as social sciences, business, and engineering.

Advantage

- It is more robust when dealing with small sample sizes, making it suitable for studies with limited data..
- It is well-suited for predictive modeling, making it a valuable tool for forecasting and decision-making.
- It can effectively model complex relationships, especially when dealing with numerous variables and latent constructs.
- It is often more efficient in terms of computational resources, and user-friendly software is available.

Result of EFA based on satisfaction rating

- 22 variables of service quality were extracted in 16 variables and were reduced in 4 latent factors.
- They are namely, "safety & security", "comfort", "time/ reliability" and "availability".
- 9 variables of personal attitude were extracted in 7 variables and reduced in 2 latent factors.
- They are namely, "perceived value" and "involvement".

Table: Results of EFA for service quality

Latent Factors	Observed Variables	Factor Loading	Variance Explained	Commonality	Cronbach Alpha
Attributes of service quality					
Comfort	a). Availability/ Maintenance of seats at bus stop (sq16)	0.850	**25.383%**	0.755	**0.885**
	b). Comfort while alighting and boarding the bus (sq14)	0.832		0.719	
	c). Level of comfort inside bus (Seat availability, spaces for standing, availability of grab handle) (sq13)	0.819		0.671	
	d). Condition of the vehicles (sq17)	0.807		0.684	
	e). Attitude of driver/ conductor (sq12)	0.795		0.637	
Safety/security	a). Security against crimes/ theft during travel (availability of CCTVs/ security personnel) (sq20)	0.719	**15.285%**	0.712	**0.800**
	b). Lighting inside vehicles (sq19)	0.787		0.622	
	c). Sense of security to women against harassment (especially at night-time) (sq22)	0.756		0.601	
	d). Real time information inside bus (sq6)	0.725		0.633	
Availability	a). Availability of walking infrastructure (like sidewalk, footpath) (sq4)	0.793	**10.966%**	0.671	**0.682**
	b). Journey time inside bus (sq11)	0.767		0.596	
	c). Availability of travel-related information at bus stops (about routes, timing, fare, and bus numbers) (sq5)	0.625		0.459	
	d). Availability/ Maintenance of sheds at bus stops (sq18)	0.600		0.365	
Time/ reliability	a). Frequency of the bus service available (sq1)	0.745	**8.547%**	0.584	**0.628**
	b). Regularity of services (sq9)	0.687		0.562	
	c). Punctuality against time (sq8)	0.656		0.464	
	d). Network Coverage [Routes and connectivity of bus to all areas] (sq2)	0.620		0.497	
Cumulative Explained Variance		**60.182%**			
Overall Cronbach's Alpha				**0.721**	

Table: Results of EFA for Personal Attitude

Latent Factors	Observed Variables	Factor Loading	Variance Explained	Commonality	Cronbach Alpha
Involvement	I am willing to recommend the bus travel to others {P8}	0.813	**47.366%**	0.813	**0.779**
	I like people who take public transit. {P7}	0.757		0.757	
	I like others to know the fact that I take public transit {P6}	0.736		0.736	
	I feel that taking public transit is consist with my lifestyle {P3}	0.659		0.659	
Perceived value	Considering the service provided, the ticket price is reasonable {P1}	0.876	**14.783%**	0.774	**0.694**
	Considering the ticket price, I believe that bus transit offers sufficient service. {P2}	0.745		0.654	
	I feel like taking public transit I help to protect the environment {P5}	0.627		0.451	
Cumulative Explained Variance		**62.148**			
Overall Cronbach's Alpha				**0.810**	

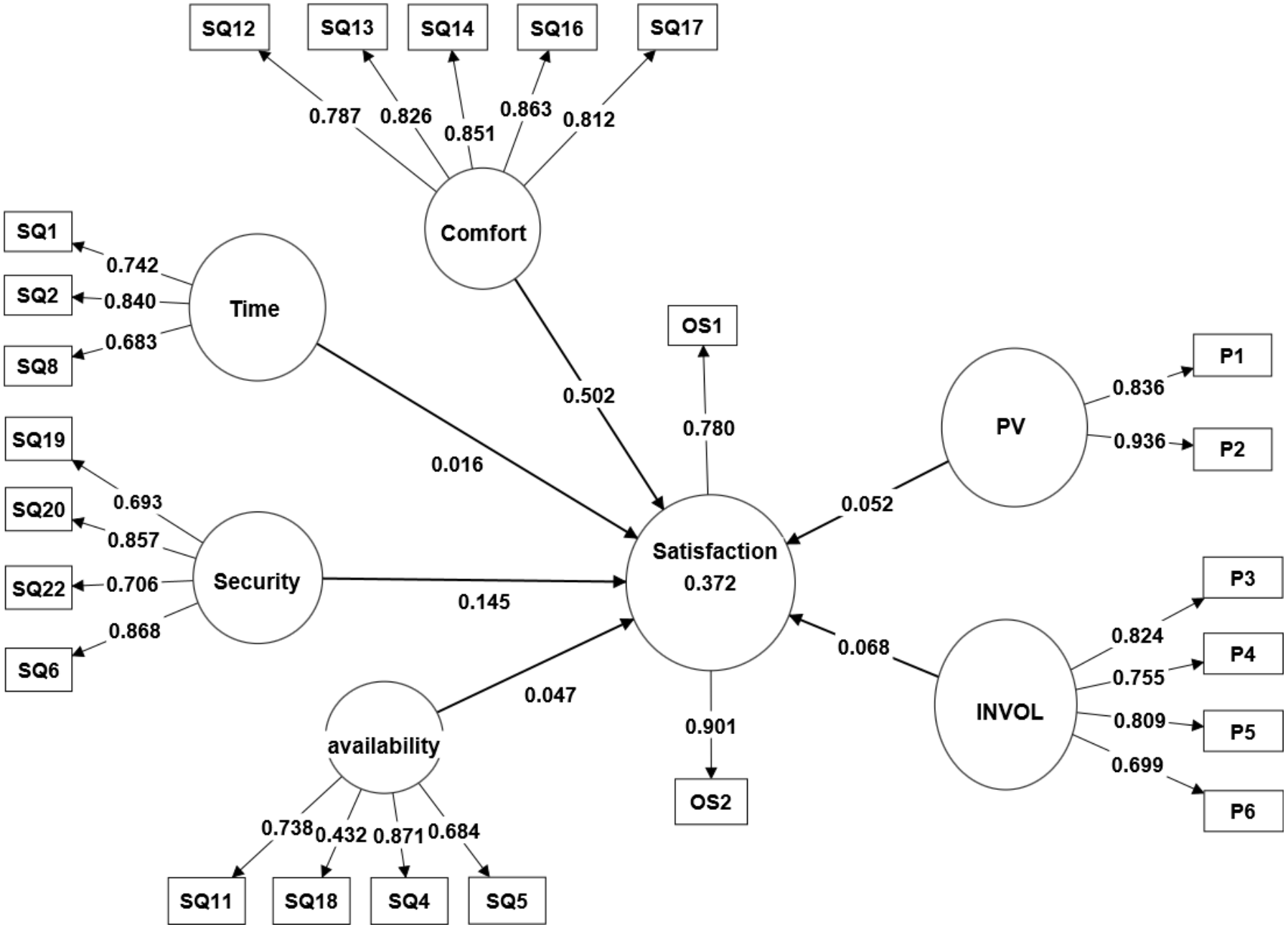


Figure : Path Analysis of Electric Buses

Table: The results of structural model: Path coefficient between the constructs

Latent variables	Notation	Standard Loading	T Statistics	p-value	CR	AVE	Cronbach's α
Comfort	SQ12	0.787	31.4	***	0.888	0.686	0.885
	SQ13	0.826	40.1	***			
	SQ14	0.851	53.3	***			
	SQ16	0.863	55.8	***			
	SQ17	0.812	34.5	***			
Safety/ Security	SQ6	0.868	34.1	***	0.885	0.617	0.8
	SQ19	0.693	12.8	***			
	SQ20	0.857	40.1	***			
	SQ22	0.706	14.0	***			
Time/ Reliability	SQ1	0.742	5.7	***	0.684	0.575	0.639
	SQ2	0.840	7.0	***			
	SQ8	0.683	4.6	***			
Availability	SQ4	0.871	6.08	***	0.775	0.489	0.680
	SQ5	0.684	5.1	***			
	SQ11	0.738	5.6	***			
	SQ18	0.432	2.3	**			
Perceived Value	P1	0.836	20.6	***	0.843	0.787	0.741
	P2	0.936	45.6	***			
Involvement	P3	0.824	25.4	***	0.825	0.598	0.785
	P4	0.755	18.3	***			
	P5	0.809	25.2	***			
	P6	0.699	11.3	***			
Overall Satisfaction	OS1	0.780	20.6	***	0.657	0.710	0.603
	OS2	0.901	58.6	***			

Table: Correlation coefficient matrix of latent constructs

	Comfort	INVOL	PV	Satisfaction	Security	Time	Availability
Comfort	1.000						
INVOL	0.403	1.000					
PV	0.358	0.486	1.000				
Satisfaction	0.590	0.315	0.283	1.000			
Security	0.273	0.107	0.115	0.304	1.000		
Time	-0.188	0.001	-0.067	-0.143	-0.357	1.000	
Availability	0.116	0.083	0.043	0.155	0.308	-0.177	1.000

Table: Summary of model fit

	Estimated model values	Recommended Values
SRMR	0.066	Less than 0.08
d_{ULS}	1.297 (HI_{95} = 1.462)	$d_{ULS} < HI_{95}$ of d_{ULS}
d_G	0.391 (HI_{95} = 0.513)	$d_G < HI_{95}$ of d_G
Chi-square	937.822	
NFI	0.722	Between 0 and 1 & closer to 1 shows better fir

CONCLUSIONS AND RECOMMENDATIONS

Conclusion

- The overall satisfaction of riders is more highly impacted by the SQ provided by the electric buses than that of the personal attitudes of the passengers.
- Among the four latent constructs of SQ, riders' overall satisfaction is highly influenced by comfort ($\gamma = 0.502$) which is followed by security ($\gamma = 0.145$), availability ($\gamma = 0.047$) and time & reliability ($\gamma = 0.016$).
- Among two latent constructs of personal attitude, overall satisfaction is highly affected by involvement ($\gamma = 0.068$) that that of perceived value ($\gamma = 0.052$).

Recommendation

Safety & security

- Arrangement of security personnel inside the bus and bus stop for the safety of women, and public bus should be provided with the panic button which directly alerts the nearest police station.
- Development of application (apps)' website to provide information regarding routes and availability of public buses in respective routes.
- Establishment of Real Time passenger Information (RTPI) systems which provides up to date information to passengers regarding their journey.
- BRT system should be introduced, and public buses should be given priority at intersection at intersection to reduces delay.
- Installation of CCTV inside the bus and at bus stops.

Continue:

Comfort

- Availability of seat, and availability of space and grab handle in case seat is full.
- Better facilities in the waiting area with a high number of seating places.
- Proper lighting inside buses so that people will feel comfortable travelling during the nights.
- Old buses in the existing fleet should be phased out through scrappage policies.

Accessibility and availability of the services

- Better frequency and network coverage of the conventional and electric buses.
- Bus route optimization to reduce overlap and ensure coverage throughout the city following demand.
- Proper walking infrastructure (availability of footpath, sidewalk, etc.) by removal of shop within 30m from center of road. Ease of access to reach the bus stop should be improved by introducing and e-rickshaw for short distances.

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Thank you.

DEFINITION OF SOME TERM

1. **Service quality**:- Difference between what customers expect from the service and what they receive.
2. **Perceived Value**: Consumer's overall evaluation of the utility of a service based on perceptions of what is received and what is provided. It is a precursor to satisfaction and behavioral intentions.
3. **Behavioral Intention**: It refers to an individual's subjective likelihood or readiness to engage in a specific behavior.
4. **Involvement**: Refers to the level of personal importance that an individual attaches to a particular situation, activity, or decision. It reflects the degree to which an individual is engaged and interested.
5. **Satisfaction**: General subjective response to a perceived discrepancy between prior expectations and the perceived performance following consumption.