A METHODOLOGY FOR COMPARATIVE ANALYSIS OF PUBLIC TRANSPORT SYSTEMS IN AFRICAN CITIES

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ABSTRACT

The large and mostly impoverished populations of African cities are dependant on public transport. In most African cities, private vehicle ownership and traffic is increasing rapidly, scheduled or formal public transport systems are declining or have disappeared altogether and the unscheduled or informal paratransit systems that have replaced them are unsafe and offer a low quality service.

A problem with public transport planning in many African cities is that public transport is either poorly planned or not planned at all. This is due to the fact that there is a lack of adequate information and planning framework to guide decision makers and that they either select inappropriate systems based on those used in developed countries or allow private operators to decide.

It is the responsibility of government to ensure that public transport systems meet the needs of the communities they serve and political decision-makers need to make the right decisions for the development of public transport. Precise and relevant performance indicators and statistics may give a clear overview of the public transport systems of cities and will help to monitor the benefits of implementing efficient systems. Therefore a need exits to develop a methodology to assess public transport systems in African cities.

The aim of this paper is to set out a methodology to describe, discuss, and compare public transport systems in African cities. The paper will only discuss the assessment methodology, and the application of the methodology will be discussed in a future paper.

1 INTRODUCTION

During the past few decades developing countries have experienced huge population growth. The increase in population has led to the increase in the demand for urban transport, especially in African cities, but the transport infrastructure in these cities is not appropriate for the current transport demand. This has caused serious road congestion and public transport systems are overloaded. Most governments have a lack of financial and human resources to meet these demands.(Armstrong-Wright, 1993; Gwilliam, 2002)

There is a shortage of public transport supply which has led to the emergence and growth of informal transport (paratransit)(Gwilliam, 2002). Paratransit operators have filled the gap between the demand for public transport, and the decreasing supply and level of service of formal public transport services. Informal public transport dominates most of the public transport markets in developing countries.

From the discussion above it is clear that public transport in developing countries needs urgent attention in order to improve the services provided and to satisfy growing demand.

A lack of adequate information and planning frameworks to guide decision makers has led to the unplanned or poorly planned public transport found in Africa today. Many cities select inappropriate public transport systems based on models from developed countries instead of developing countries (Razat et al, 1998). Political decision-makers and the regulatory stakeholders involved in public transport have to take the responsibility to ensure that the systems of their country meet the needs of the communities they serve and they also need to ensure that they establish public transport systems that they can sustain with the resources available. Each country and city has different public transport goals and objectives and the public transport system of each city needs to be designed and evaluated in relation to the context of the city and resources available. Performance indicators would give a clearer overview of the systems of cities and make it possible to compare the systems of different cities. There is therefore a need to develop a methodology to assess transport systems in African cities.

The purpose of this paper is to describe the development of a methodology able to assess the public transport system of a city; more specifically of cities in Africa where resources are limited. The methodology includes steps to describe, discuss, evaluate and compare the public transport systems of cities. An assessment of quality of performance in terms of the prevailing conditions and the objectives of the country and the city will be useful to identify the public transport issues which the regulatory stakeholders and public transport operators should improve. It will also give context to the desired performance levels to make them appropriate to the city and country rather than simply adopting them from other cities and countries where different conditions exist. This paper discusses the assessment methodology that was developed to evaluate the performance of public transport systems. The application of this methodology to three case cities in Africa; namely Cape Town, Dar es Salaam and Nairobi and will be the subject of a future paper.

2 RESEARCH METHODOLOGY

The research methodology used five phases. The first phase was a literature review to determine the characteristics and performance measures of urban public transport systems. These characteristics and performance measures will be used to describe, discuss and compare the public transport systems of the case cities. The literature review is also used as a source to identify methods that can be used to evaluate public transport systems.

The second phase served to develop a methodology to describe and discuss urban public transport systems. A questionnaire was developed to interview stakeholders in the case cities of Cape Town, Dar es Salaam and Nairobi. These interviews were used to collect data and to obtain an understanding of the current public transport systems in these cities (The structure of the questionnaire is attached as Appendix B).

The third phase was the collection of data from case cities to translate the list of theoretical characteristics, goals, objectives and performance measures into a shorter practical list.

The fourth phase led to the development of the methodologies to evaluate and compare urban public transport systems.

The fifth phase which is currently underway is to apply the methodology in the three case study cities.

3 DEVELOPMENT OF THE METHODOLOGY TO DESCRIBE AND DISCUSS PUBLIC TRANSPORT SYSTEMS

3.1 The Characteristics of Public Transport Systems

A review of literature produced a set of characteristics and components of public transport systems theatre important to describe and discuss the public transport systems of cities. Table 1 shows how these were grouped into 23 components within 4 themes; namely: institutional and regulatory framework, public transport network, public transport modes, and financial issues. The components were further defined into 122 characteristics.

Table 1: List of the components of a public transport system that can be used to describe the public transport systems of cities

	Theme		Components
1	Institutional and regulatory framework	1.1	Stakeholders
		1.2	Regulatory framework, legislation
		1.3	Public Transport policies
		1.4	Industry structures
2	Public transport network	2.1	Transportation demand & usage of modes
		2.2.	Transport plans
		2.3	Transport maps
		2.4	City characteristics
		2.5	Infrastructure
		2.6	Network structure, size and performance
		2.7	Non-motorised transport
		2.8	Traffic Management
		2.9	Congestion
3	Public transport modes	3.1	General and operational aspects
		3.2	Infrastructure
		3.3	Vehicle fleet
		3.4	Main routes
		3.5	Stakeholders
4	Financial issues	4.1	Funding
		4.2	Fares
		4.3	Costs
		4.4	Subsidies
		4.5	Economic background of the city

3.2 A methodology to describe and discuss urban public transport systems

Public transport systems can be described and discussed using their characteristics and their performance. However, a long list of characteristics needs to be shortened to be practical.

To this end a spreadsheet was developed (an extract of which is shown as Table 2) that shows:

a) Whether a characteristic was referred to in the literature reviewed. This is shown as a “1” for each characteristic for each text.
b) The number of references that mentioned each characteristic. This was calculated as the sum of “1”s; and is shown in the third last column.
c) The percentage of references that mentioned each characteristic. This is shown in the second last column.

d) The most relevant characteristics. The characteristics that were mentioned in more than 40% of the references are highlighted in the last column as “y”. In this way the original list of 122characteristics was reduced to 21characteristics.

e) Additional important characteristics. On closer inspection, it was found that certain characteristics that were not frequently mentioned were the central characteristics of individual papers. An additional 36characteristics were identified as important and are highlighted as “i” in the last column.

Table 2: Extract from the spreadsheet used to select public transport characteristics

	Methodology to choose the characteristics to describ																		
	Literature (References)	1	2	3	4	5	6	7	50	51	52	53	54	55	56	57			40%
	Public transport characteristics																Usage Sum	Usage %	use yes/ no
2	Regulatory framework		1	1	1	1	1					1		1	1	1	17	67	y
a	PT Regulation			1	1	1								1	1	1	12	46	y
b	Markets											1		1			6	25	
c	Contract types											1					2	8	
d	Vehicle & driver licensing			1	1									1	1		6	25	
e	Route allocation			1										1	1		6	25	
f	Monitoring of service quality			1													4	17	
g	Vehicle inspections			1	1										1		5	21	
h	Operating rules			1											1		3	13	
i	Market Entry			1										1	1		7	29	i
j	Enforcement						1							1			5	21	
3	PT Policies		1	1		1	1		1			1		1	1	1	19	75	y

The final list of the most important characteristics of public transport systems derived from the literature review is shown in Appendix A.

Because of time limitations not all the possible literature on public transport systems was analyzed and the review of additional literature could lead to some changes in the list of characteristics. However, the quality of the texts reviewed provides confidence that none of the most important characteristics have been omitted.

While these characteristics are considered adequate to describe and discuss public transport systems they are not adequate to compare public transport systems. A comparison needs to take local factors into account since public transport systems operate in specific socio-economic conditions and have to achieve specific development and transport objectives. The characteristics will need to be contextualized to be usable to evaluate and compare public transport systems.

3.3 Data collection

The questionnaire (Annexure B) was used to collect information on the public transport systems in Cape Town, Dar es Salaam and Nairobi. It was structured according to the four public transport themes that were identified from the literature review and also included macro performance indicators. Meetings were held in each city with urban transport planners, city planners, city council representatives and representatives of commuter rail (where applicable), bus and paratransit operators.

Experience in using the data collection tool found that;

a) The questionnaire was too lengthy. Some of the interviews continued for over two hours,
b) It was not possible to collect all the necessary data from each interview,
c) The perceptions of respondents in the same city did not always agree with each other; and
d) In Nairobi and Dar es Salaam there is not much information on the customers' perception of the service quality.

The sample size of respondents was not intended to be statistically significant. Nevertheless, the calibre of respondents gives confidence to the data collected. The data collected from the interviews held in each city were augmented with secondary data from transportation and other studies and reports for the three cities.

4 ASSESSMENT OF THE PERFORMANCE OF PUBLIC TRANSPORT SYSTEMS

The first three phases of the research methodology focused on the themes and components and characteristics of public transport system that are used to describe and discuss public transport systems; while phases four and five focus on the development of Key Performance Indicators (KPIs) and comparison of the calculated KPIs across the cities. (Phase five is not discussed in this paper.)

From the literature review it was realized that in order to do a comparison of the performance of public transport systems across cities, KPIs need to be determined and calculated for each city.

4.1 Performance measures

Performance monitoring and evaluation of public transport systems is important to ensure that public transport services are provided within acceptable standards. Cities can use performance measures to help them improve their provision of public transport services (Ryus, 2003). Governments should monitor the public transport service provided by operators to ensure that goals and objectives are being met and that public transport users are satisfied with the service.

Performance measures provide regulatory stakeholders with data on past trends, current circumstances, existing concerns and unmet needs. Ryus (2003) wrote "*What gets measured gets attention*".

Public transport performance evaluation can be viewed as a continuing process and the following steps should be used to perform the evaluation process(Kelley, 1982; Ryus, 2003):

a) The establishment of the goals and objectives of the public transport system.
b) Development of performance measures that relate to the stated goals and objectives and reflect the criteria of effectiveness and efficiency.
c) The development and application of standards that can serve as benchmarks against which the measures can be compared.
d) Testing and implementing the performance measures.
e) Continuous monitoring and evaluation over time.
f) Integration of results into stakeholders' decision-making.

TRB (2003) describes a public transport performance indicator as a quantitative or qualitative factor used to evaluate a particular aspect of public transport service. Public transport performance indicators are values that represent the production, consumption, quality and the operating and financial characteristics of public transport services.

Talley (1986) describes two methods whereby appropriate performance indicators for evaluating public transport systems can be selected; namely:

a) By specifying the public transport objectives (Talley & Anderson, 1981), or
b) By specifying the criteria that must be satisfied by the selected performance indicators(Fielding & Glauthier, 1976).

As mentioned earlier, performance measures must relate to the goals and objectives which are to be met. Since this study was aimed at developing a methodology to evaluate and compare public transport systems, it needed to develop a list of possible goals and objectives (wider than a specific city or public transport system would aim to achieve); and then develop indicators to evaluate performance against each of these.

There are various criteria that can be used to select the most appropriate set of performance indicators to evaluate a public transport system. The criteria used for this study are the following:- the performance indicators must be acceptable to all the parties involved, the cost to collect data, consistency with goals and objectives of the government, the availability of data, data quality, easy to understand, measurability, reliability, time needed to collect data, uniqueness of measure, utility and the variety of measures (Drosdat & Herbert, 1977; Fielding, Gilbert & Dajani, 1975; Glauthier& Lave, 1977; Kelley, 1982; Ryus, 2003; Talley, 1986; VTPI, 2010; VTPI, 2010b).

4.2 Development of a methodology to evaluate and compare urban public transport systems.

From the literature review, the interviews with the relevant stakeholders, and the reports of the public transport systems of cities, it emerged that the methodology to evaluate and compare public transport systems required the following three components:

a) A method to select measures of performance that can be used to evaluate a system in terms of the goals and objectives of the urban area.
b) A method to input the necessary information required to calculate the performance measures.
c) A method to calculate and display the performance measures.

4.2.1. Towards a methodology to evaluate and compare urban public transport systems

The following steps were followed during this phase:

a) Deriving Key Performance Indicators (KPIs) from goals and objectives.
b) Determining which data are required to estimate the KPIs.
c) Collection of data to determine KPIs.
d) Calculation of KPIs.
e) Comparison of PT systems.

4.2.2. Key Performance Indicators (KPIs) from goals and objectives

Key Performance Indicators (KPIs) to evaluate a city's public transport system need to be derived in relation to the goals and objectives of a city and not be limited to efficiency measures of a city's public transport system. Litman (2010) describes goals as general

desired outcomes; and objectives as specific, measurable ways to achieve goals. The process therefore requires the translation of each goal into one or more objectives and each objective into suitable KPIs that can be used to evaluate and measure the performance of the city's public transport system

Table 4 shows the list of possible public transport goals, and the related objectives and KPIs from which the user can choose the most appropriate. Some of the KPIs cannot be evaluated in terms of the public transport system as a whole because they apply to specific modes (indicated with a light blue background in table 4). The KPIs have been contextualized in terms of the area of a city, the income per capita, population size and passenger volumes.

Table 4: Goals objectives and performance measures

No	Goals	Objectives	KPI
1	Improve accessibility and mobility provided by the public transport system	To provide appropriate public transport choices	% Population that has access to all 3 PT modes
		To provide affordable access to the public transport system	Average % of income spent per month per capita on PT
		To provide public transport systems that are accessible to everyone	% Population within walking distance from PT facility (1000m)
			# PT stops per 100sq km's
			# PT seats per 1000 population
		To increase the mobility of public transport systems	% of Population that can reach employment opportunities within 1 hour journey time
		To provide a public transport system that is universally accessible	% of Public transport vehicles that are universally accessible
2	Affordable public transport	To provide a public transport system that is affordable to everyone	Average % of Household income spent on PT per month
			% of PT users that spend more than 10% of their income per month on PT
			Average PT fare per 10km trip
3	The subsidies for public transport must be beneficial to the poor	To provide public transport subsidies that is beneficial to the poor	Average public transport subsidy per low-income passenger per year
4	Higher priority to public transport than private transport	To invest in dedicated public transport infrastructure and inter-modal connections	The percentage of dedicated PT network out of the road network of a city
			# Daily PT Passengers per 1000 population
5	Change the modal split in favour of public transport	To move towards a city-wide modal split in favour of public transport	Modal Split, Public Transport : Private Transport

Table 4: Goals objectives and performance measures (cont.)

4.2.3. Data required to estimate the KPIs

No	Goals	Objectives	KPI
6	Environmental sustainability	To reduce the greenhouse gas generation	Emissions per PT vehicle km per year
			Average vehicle-km's per litre of fuel consumed
7	Develop a transport system that drives economic growth	To create job opportunities through the development of the public transport system	% of Population have jobs in the public transport sector
8	Service Quality & Convenience	To provide a public transport system that is convenient to the customers	% Population within walking distance from PT facility (1000m)
			# PT stops per 100sq kms
			PT Service hours per day as a % of the total daily hours
			Average load factor in the peak period (Passengers per seat)
			Average # transfers per passenger per trip
		To improve the service quality of the public transport system	% of Population that are satisfied with the quality of PT service provided
			Average journey time in the peak period from home to work
			Average journey speed in the CBD in the peak hour (Road-based PT)
		To improve the reliability of the public transport system	% of Scheduled public transport vehicles that arrive on-time at a PT stop
		To provide frequent public transport services	Frequency in the peak hour (minutes)
		To provide cost-effective public transport services	Operating cost per passenger-km
9	Safety & Security	To reduce injuries & fatalities on all public transport modes	# PT Accidents per 100 000 PT vehicle-km's
			# PT Accidents per 1000 population
			# Fatalities per 100 000 PT vehicle-km's
			# Fatalities per 1000 population
			Accident cost as a % of the GDP of a city
		To improve personal security on the public transport system	# PT Crime related incidents per year per 1000 population
		To improve pedestrian safety	# Pedestrian accidents per 100 000 PT vehicle-km's
10	Equity	To provide a public transport system with equitable basic access and affordability of public transport for all	% of Population within walking distance to a PT stop (1000m)
			% of PT users that spent less than 10% of their income per month on PT.
11	System efficiency	To provide a public transport system that operates to improve the overall efficiency & competitiveness of the City	# Km of road on which PT service is provided per 100km^2
			# Private vehicles per 1000 population
			% of the Population that uses Public Transport
			Average age of the vehicle fleet
		To provide a public transport system that operates to improve the overall system costs of the city at optimum levels.	Total cost per PT vehicle-km
			Operating cost per PT vehicle-km
		To promote high density residential development along public transport corridors	# PT stops within 1000m from a high household density area
12	Rehabilitation of road network	To rehabilitate key roads that are currently in a poor condition	% of roads that are in a bad condition in the transport road network of the city
Sources: Bruun, 2005; City of Cape Town 2006a; City of Cape Town 2006b; City of Johannesburg, 2003; Kelley, 1982; Litman, 2010; Talley, 1986; Vuchic, 1981.			

Data are needed to calculate a KPI. Gleave et al. (2005) warn that it is often relatively straightforward to determine how performance should be assessed, but in practice it may be more difficult to obtain the necessary information from which the KPIs can be measured. The authority or government responsible for the evaluation of the public transport system may have to consider carefully whether the cost of collecting the information which is required to calculate specific KPIs can be justified.

This step of the methodology will show the public transport data that is required to calculate a KPI. The selection criteria mentioned in section 4.1 are used to determine the final set of KPIs that will be used.

4.2.4. Collection of data to determine KPIs

The data needed to calculate the KPIs can be obtained from three main sources; namely available data (literature, studies, reports and data already collected) personal interviews in a city, and primary data. Since resources are scarce in African cities, KPIs should be used that require the least amount of additional data. Therefore the first step in setting up an evaluation system, is to record the data that is available and then to decide whether the missing data should be collected through a more extensive data collection process or whether the specific KPI for which additional data were required should be excluded from the evaluation process. This will adversely affect the evaluation of the performance if too many of the most important KPIs have had to be excluded because data were unavailable.

4.2.5. Calculation of KPIs

The KPIs are easy to calculate once all the necessary data is available. KPIs usually present values that represent efficiency, effectiveness, production, consumption and quality. The KPIs can be expressed as percentages, a whole numbers or ratios.

4.2.6. Comparison of PT systems

The values calculated for the KPIs serve to measure the performance of a city's public transport system. Because they have been contextualised, they can also be used to compare the performance of a public transport system:

a) With other different public transport systems within or across cities...
b) Against benchmarks; and
c) Across preceding years for a specific city, to determine whether the public transport system of a city have improved.

4.3 The spreadsheet model

Figure 1 shows a graphical layout of the methodology explained above. This has been converted into a spreadsheet model.

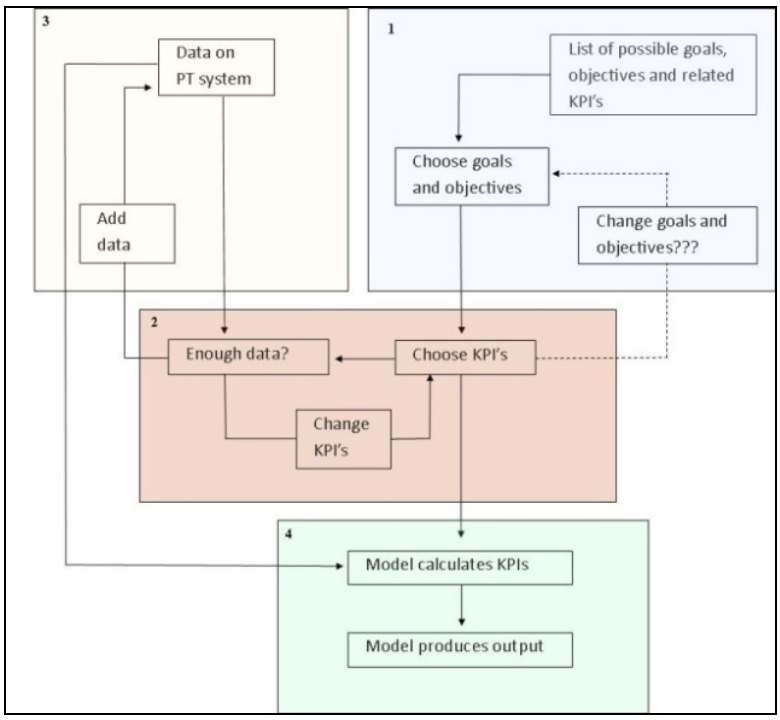

Figure 1: Methodology to evaluate public transport systems

The model has four steps; namely:

a) Step 1 involves the process of choosing the goals and objectives from the list of possible goals, objectives and related KPIs.

b) Step 2 involves the process of choosing the KPIs, this will be done with the help of selection criteria. After the KPIs are chosen the data required for each KPI will be presented.

c) The user can go to step 3 to enter the data required, or the user can change the KPIs selected and could even go back to step 1 to unselect some of the goals and objectives selected. During step 3 the data required to calculate the KPIs will be entered by the user. There is an iterative process between steps 2 and 3 to input the required data.

d) Step 4 calculates the KPIs and produces the output.

5 CONCLUSION

This paper discussed a methodology to describe, discuss, evaluate and compare urban public transport systems. It has been developed on the basis of a comprehensive literature review to identify the most important characteristics and performance measures. The characteristics were grouped into four themes and 23 components to firstly produce a long list which was then systematically reduced to be more practical.

Typical goals and related objectives for public transport systems, as well as related key performance indicators have been identified from the literature. The performance indicators have been related to the information needed to calculate them. The need for, the availability of, and the cost of collecting specific information can therefore be taken into account when deciding which key performance indicators to apply.

A spreadsheet model has been developed to assist in the process to determine the most appropriate KPIs and to calculate their values. The model will facilitate the evaluation of public transport systems in African cities.

One of the challenges faced in this research has been to decide which KPIs should be used to evaluate the public transport systems of the case cities. It was realized that in order to decide on a fair set of KPIs for each case city, the goals and objectives for a city needs to be identified. These objectives will determine the set of KPIs that are relevant for each city. African cities usually do not have up to date information required to evaluate the KPIs; and resources to collect this information is usually scarce. In order to overcome this problem, selection criteria can be used to select the appropriate KPIs that trade off between the benefits of being able to use the most appropriate KPIs and the resources (financial and human) required to determine these KPIs.

This paper has only discussed the assessment methodology developed to describe, discuss, evaluate and compare public transport systems of case cities. The next step of the research is to apply this methodology to the three case cities of Cape Town, Dar es Salaam and Nairobi and will be discussed in a future paper.

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ANNEXURE A: LIST OF THE MOST IMPORTANT CHARACTERISTICS OF PUBLIC TRANSPORT SYSTEMS

Theme, component and characteristic		y = yes i = included	usage %
Theme 1. Institutional and regulatory framework (In 41% of the references)			
1	Stakeholders	y	65
2	Regulatory framework	y	70
a	Public Transport (PT) Regulation	y	48
3	PT Policies	y	78
a	Fare Policy	i	35
b	Subsidy policy	i	13
c	TDM policies	y	43
d	Goals & objectives of PT	i	4
4	Industry Structures	i	13
Theme 2; Networks & City structures (In 71% of the refs)			
1	Transportation demand and usage of modes	y	70
a	Modal Split	y	55
b	Daily passenger demand	y	50
c	Daily motorized trips	i	33
2	Public Transport Network	y	60
a	# Routes & # Main routes per public transport mode	i	33
b	Route km's in network	y	45
3	City characteristics	y	73
a	Area	i	28
b	Population & Population growth rate	i	35
c	Population, housing and employment density	i	38
4	Infrastructure	y	48
a	Terminals & Stops	i	38
5	Congestion	i	33
6	Traffic management	i	28
7	Integrated PT system	i	5
8	Transportation plans	i	25
9	Non-motorised transport	i	18
PT Modes (In 80% of the references)			
1	General	y	87
a	History & development of the mode, Current situation	i	18
b	Passenger volumes	y	60
c	Operating and capital cost	y	56
d	Service type provided and service hours	i	36
e	Operating schedules & routes	i	11
2	Infrastructure	y	67
a	Length of network (routes)	i	33
b	# Stations, # Terminals, # Stops	i	27
c	Capital expenditure on track, stations and depots. Capital cost per km, Funding	i	31
d	Operating environment, ROW	i	22
	3.PT Modes(Referred to in 80% of the references)		
3	Vehicle fleet	y	80
a	Vehicle description (vehicle types, numbers, design, technology)	i	31
b	Capacity, crush load capacity, design capacity	i	36
c	Capital cost, funding	i	31
d	# Vehicles in fleet	y	44
e	Age of the vehicles	i	24
f	Vehicle km's	i	36
4	Main routes for peak periods & off-peak periods	y	69
a	Service frequency	i	24
b	Passenger volumes (pphpd), Max capacity (pphpd), Peak hour pass demand	y	40
c	Average travel speed (peak hour, off-peak)	i	36
d	Accessibility (average distance to stops, between stops)	i	23
5	Stakeholders, Operators, Authorities	i	36
Theme 4. Financing (In 66% of the references)			
1	Economic background of the city	i	35
2	Subsidies	i	38
3	Operating cost, Capital cost (per passenger or per km)	y	78
4	Fare box revenue, Revenue/cost ratio	i	27
5	Funding	i	30
6	Fares	i	38

ANNEXURE B: THE STRUCTURE OF THE QUESTIONNAIRE USED TO COLLECT DATA FROM THE CASE CITIES

1. INSTITUTIONAL AND REGULATORY FRAMEWORK

1.1 Stakeholders
1.2 Regulation of Public transport Policies
1.3 Public transport policies
1.4 Delivery of Public transport services

2. PUBLIC TRANSPORT NETWORKS

3. BUS TRANSPORT / RAIL TRANSPORT / PARATRANSIT

3.1 General
3.2 Infrastructure (Map showing network and stations?)
3.3 Vehicle Fleet

4. FINANCIAL ISSUES

4.1. Operating Cost
4.2. Capital Cost
4.3. Subsidies

5. MACRO-PERFORMANCE INDICATORS

5.1. Accessibility
5.2. Comfort
5.3. Reliability
5.4. Travel time
5.5. Affordability
5.6. Safety & Security
5.7. Sustainability