ASSESSMENT OF STAKEHOLDER NEEDS AND SDSS TOOL APPLICATION FOR COLLABORATIVE BRT INFRASTRUCTURE PLANNING

GRACHEN ONEKO
February, 2017

SUPERVISORS:
Ir. M. J.G. Brussel
Dr. J. Flacke

ASSESSMENT OF STAKEHOLDER NEEDS AND SDSS TOOL APPLICATION FOR COLLABORATIVE BRT INFRASTRUCTURE PLANNING

GRACHEN ONEKO

Enschede, The Netherlands, February, 2017

Thesis submitted to the Faculty of Geo-Information Science and Earth Observation of the University of Twente in partial fulfilment of the requirements for the degree of Master of Science in Geo-information Science and Earth Observation.

Specialization: Urban Planning and Management

SUPERVISORS:
Ir. M. J.G. Brussel
Dr. J. Flacke

THESIS ASSESSMENT BOARD:
Prof.dr.ir. M.F.A.M. van Maarseveen (Chair)
Dr. K. Pfeffer (External examiner)
Ir. M.J.G. Brussel
Dr. J. Flacke

ABSTRACT

Bus rapid transit (BRT) projects have been on the increase in developing countries. In some Latin and Asian cities, planning for BRT systems has become a mainstream practise in transport planning policies. This trend has been attributed to the success level of Bogota's BRT system, known as TransMilenio, which is reported to have managed to reverse and restructure its public transport system from unregulated to relatively structured systems. An underlying factor of its success is stated to be the process of stakeholder engagement in the planning process. But despite developing cities adopting similar strategies, cases of similar positive outcomes have been reported to be few. From this perspective, this study aims at understanding the generic planning process of BRT infrastructure. Focus is on how decisions are made with stakeholders, so as to conceptually design a spatial decision support tool (SDSS) for collaborative planning.

The initial step of the research was an in depth review of BRT planning processes. This involved the reviewing of institutional BRT planning models which focused on the model presented by the lead BRT initiative agency in developing cities, ITDP. In addition was the in-depth review of BRT cases of TransMilenio planning process and the field case of Dar es Salaam's BRT planning process. The later case included a review and analysis of stakeholder insights regarding the need for a SDSS tools in BRT planning. This strategy was to help identify the main BRT tasks for infrastructure planning, the spatial decision problems and the tools used in the planning process, that facilitate decision making and could resultantly be used in developing a SDSS.

The study indicates that key BRT infrastructures are the corridors and transfer stations. The main planning tasks associated with them include stakeholder analysis, demand analysis, infrastructure design and system integration planning. In matters of decision making, the processes is often limited to top level stakeholders and not much is documented on the actual process of deliberating with stakeholders. However, multi criteria tools and techniques and GIS are applied in some deliberating sessions both directly and indirectly. It is during deliberations that spatial decision problems arise. A main source for the decision problems is the conflict in trade-offs between cost and space. The results of this has been the locating of BRT in conflicting areas.

From this insight, the study concludes that for the case of Dar es Salaam's BRT, its agency could utilise a BRT–MCSDSS in deliberation and review meetings to manage the decision making process with stakeholders. Application of the tool is made to fit the decision making process of identifying suitable sites for transfer stations. The tool structure proposes the use of AHP technique to make the deliberation process flexible, systematic, and transparent, together with GIS spatial analyst tools to visualize, in virtual space settings, the impacts of stakeholder decision before implementation.

ACKNOWLEDGEMENTS

For the trust, for the favour, for the reminder that it is not by my own strength, but by Your mercy and grace. Always I shall acknowledge, this far, You have brought me. Thank you. To my mentor Wangari Maathai, I remember, “Every person who has ever achieved anything has been knocked down many times. But all of them picked themselves up and kept going, and that is what I have always tried to do.”

It is with sincere gratitude that I thank UT/ITC/PLUS (Excellence scholarship) for the challenge presented to pursue education and emerge empowered. To my supervisors, Ir. Mark Brussel and Dr. Johannes Flacke, I am of few words and meetings but to express the amount of gratitude I have for your honesty, guidance, support, faith in my capabilities and patience for my African timings, I have no words.

Thank you Dar es Salaam, Tanzania, for allowing me to learn.

UPM class of 2016-2017, thank you for the new friendships.

My brothers and sister from Team Kenya, for keeping me sane, I am forever indebted.

Saving the best for last, My Great Ombam-Oneko Family, there since 1987. I appreciate you. Everything I have ever achieved has resulted from you always seeing me through what I can do and never letting me give up. From the moment we called the embassy to ask if this opportunity was real (Aunt Tina) to the Mbuzi funds drive to make sure I boarded the plane (Tshatsha). I want to say thank you. Mama Sila, I love you beyond words for teaching me patience, even though I fail, I keep trying. Aunt Regina, my mentor number two, I stand taller with knowledge. Mama King, I made sure I laughed and danced in Europe, Aunt Dorothy, Aunt Mary, thank you for the inspirational messages on face book, I read them. Uncle Charles and Uncle Austin thank you for making me an Eagle. Aunt Roselyne and the Oneko Family prayer group, Amen. To my big brother, Osewe, thank you for getting a masters cause that makes the two of us. Thank you for keeping me in check. To all my brothers and sisters English insists I call cousins, thank you for the prayers. To my extended family, the Sugawara’s, Arigato goziamasu, for introducing me to the world outside my own. To the Moll’s, dank ya, for speaking in English and giving me a home away from home.

Thank you all!

Now off to the next chapter

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1. INTRODUCTION

This research study looks at the planning process of bus rapid transit systems, BRT, with the intention of documenting and interpreting the roles of planners in the planning process, how they are impacted by the actions of key decision makers and other key stakeholders. The goal of the research is to identify planning tasks that could potentially benefit from a collaborative spatial decision support system, SDSS. The case study is Dar es Salaam's BRT system, DART.

1.1. Background and Justification

Urban planners are responsible for providing inhabitants with infrastructure systems that are adequate and efficient for supporting everyday urban functions (El-Gohary, Osman, & El-Diraby, 2006). But rapid urbanization has led to expanding populations, increased economic activities and motorization concentrating in few and localized urban areas (Gwilliam, 2002). Consequently, road transport systems in such areas have been characterised by heavy traffic congestion, increase in traffic related accidents, decline in public transport usage, environmental degradation, and inequality against socially vulnerable groups (NIUA, 2015). To address this, transport planners have identified mass transit technologies in the form of bus rapid transit (BRT) systems as viable solutions.

BRTs are described as high performing modes of public transport that combine the quality of rail and flexibility of buses, and run on designated street lanes to deliver improved transport services to the urban population (ITDP, 2007b). It has the potential to reduce travel times for passengers, reduce emissions from vehicular travels, improve mobility and improve public health and safety (Carrigan, King, Velasquez, Raifman, & Duduta, 2013). Global reports have stated that by late 2011, BRT systems had been implemented in 120 developing cities (Hidalgo & Gutiérrez, 2013). To explain this trend, Hidalgo and Zeng (2013), describe BRT planning and implementation practises as having tipped from being a concept exhibited in a few cities to an exponential growth of adoption and actualization of the concept in many cities that makes it relatively unstoppable. The concept of bus rapid transit (BRT) despite its initial emergence in Curitiba, Brazil in 1974, tipped after the implementation of the BRT system in Bogota, Colombia, known as TransMilenio. TransMilenio has made the concept of BRT gain international recognition as a sustainable solution to public transport planning problems (Hidalgo & Zeng, 2013). In Latin America and Asia, BRT planning has become a mainstream practise in transportation (Figure1). In Africa, however, the concept of BRT systems is still emerging having been implemented in only four cites. The fourth city being the recent Dar es Salaam BRT known as DART that became operational in May 2016.

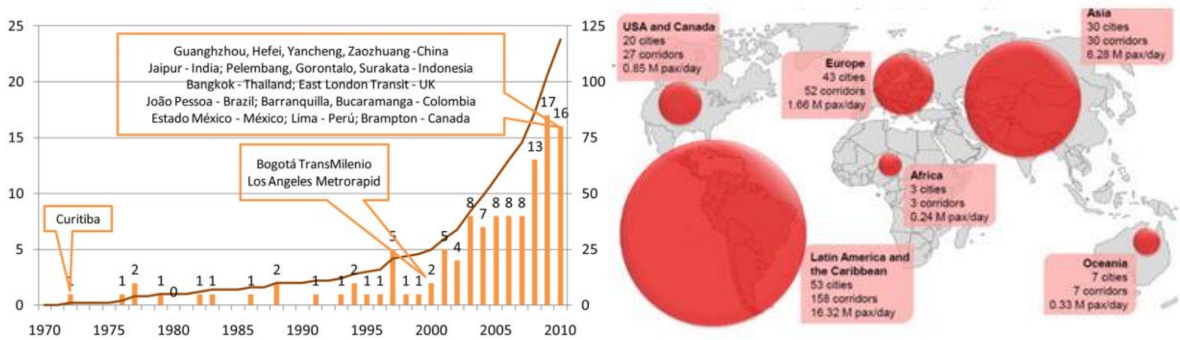


Figure 1Rise of cities with BRT systems between 1970 -2010 and a global overview

Source: EMBARQ website

In Bogota, prior to the TransMilenio, the public transport system was characterised by the general incapacity of transport authorities to control the oversupply of public bus fleets. This led to low quality public transport services with high levels of traffic congestions, excessive passenger travel times, and high levels of traffic related accidents for bus users (Cain et al., 2006; Hidalgo, 2002; Hidalgo & Graftieaux, 2010). The approach taken to address the problem was for TransMilenio BRT system to be planned using a collaborative approach with stakeholders. The concept of collaborative planning was to help planners understand and incorporate stakeholder needs and concerns in the planning process. This in turn provides amenities that safeguard the inhabitants social well-being and economic development (Olander & Landin, 2005; Prouty, Koenig, Wells, Zarger, & Zhang, 2016). Some reports have attributed this approach as an important factor to consider to prevent BRT systems from failing (Lindau, Hidalgo, & de Almeida Lobo, 2014).

With TransMilenio BRT, which was planned and implemented under four year (1998-2000), the city of approximately 7 million manages to move an average peak capacity of 45,000 passengers per hour per direction (pphpd). Such figures dispel concerns relating to high capacity mobility of passengers in densely populated developing cities (Carrigan et al., 2013; Hidalgo, 2005). Environmental reports have described the system as a cleaner technology responsible for the decline in SO^2 emissions by 43% in Bogota (Carrigan et al., 2013). In addition, traffic related accidents have reduced which has been associated with the population's behaviour shift from using personal cars to using BRT buses (Carrigan et al., 2013; Hidalgo, 2002).

These reports have made TransMilenio a model case for planners in cities where road-based public transport is the dominant means of accessing urban activities like employment or public services (Cervero, 2000). But the services are offered by private operators in a system of low performing infrastructure inclusive of vehicles and roads and where the relevant authorities have a challenge in ensuring proper governance (Cervero, 2000; Pojani & Stead, 2015). In African cities where BRT systems have been implemented, focus has been to restructure the often unreliable and inconvenient formal bus services as well as the disorderly informal transport sector of paratransit systems that dominate road-based public transport. (Pojani & Stead, 2015). Paratransit systems in this study are defined as fleets of informal and diverse collection of low performance minibuses, three wheel taxis or buses that provide on-demand mobility services for areas lacking formal transit supply, but increase the systems cost in the form of increased traffic congestion, accidents and travel time (Cervero, 2000; Pojani & Stead, 2015; Schalekamp & Behrens, 2013).

With the common aim of wanting to adequately satisfying the transit needs of the city's population planners have adopted the similar planning strategies as were applied in TransMilenio. This has included the use of TransMilenio experts in setting up the BRT systems. For the city of Lagos's Nigeria, its BRT system LAMATA started operations, in 2008, Cape Town's BRT, known as My CiTi, started operations in 2010, Johannesburg's Rea Vaya in 2009, and more recently Dar es Salaam's DART in 2016 (ITDP, 2016). The planning of these BRT systems engaged paratransit stakeholders in an attempt to gain support for BRT projects from existing public service providers. Segregated bus lanes have been provided (except in LAMATA) to improve reliability of the buses by reducing the interaction with mixed traffic lanes. In addition, independent planning agencies specialized in the managing the BRT systems have been established similar to the model BRT case of TransMilenio. However similar reports of the level of success and benefits have been described as falling short of expectations.

To investigate this, the case study area of Dar es Salaam, is used to understand the BRT planning and decision making process with stakeholders. Dar es Salaam is selected as a suitable case due to its recent implementation of its first phase and a planning process of its second and third phase currently ongoing. This study hence assumes that most of its key project stakeholders are active and thus, information on the planning process with stakeholders would be better illustrated.

Since diverse group of actors in planning offer a range of viewpoints, experiences and expertise that improves other stakeholders' ability to understand a project the decision making process tends to improve. At the same time however the diverse information can lead to an abundance in alternatives for decision makers to choose from creating decision problems (Mysiak, Giupponi, & Cogan, 2002). To help manage the large amounts of information for stakeholders to make well-informed decisions and also facilitate their participation in the decision making process, the fields of decision science and information technology have developed decision support systems, DSS: SDSS when they deal with spatial decision problems. These are defined as computer based interactive system of information and analysis models that can support a group in achieving higher effectiveness in resolving decision problems experienced in a planning task (Mysiak et al., 2002; Sugumaran & DeGroote, 2013).

1.2. Research Problem

For the city of Bogota, the TransMilenio BRT has transformed the public transportation system and led to an improved social, economic and environmental setting. But for some of the developing cities that have applied similar planning strategies, expected levels of success have not been achieved. Studies investigating the reasons for the failures of implemented BRT systems have described poor stakeholder engagement as being among the contributing factors (Agyemang, 2015; Lindau et al., 2014; Schalekamp & Behrens, 2013). Lindau et al, 2014 discusses the lack of alignment among stakeholders and their roles and the lack of community participation and input that have imposed delays challenging decision making in the planning process. The SDSS tools that could facilitate stakeholders in the decision making process are described as having failed to fit the user support needs for deliberations. Resultantly limiting their usefulness and application in real planning situations (Jankowski, 2006; Plezer, 2016, in press). This scenario sets the base of the research.

1.3. Research Objective and Questions

The main objective of this research is to examine BRT planning processes and to understand the settings in which stakeholders participate in decision making so as to conceptually design a collaborative SDSS application framework for BRT infrastructure using the case of Dar es Salaam bus rapid transit, DART.

1. To understand the BRT infrastructure planning process
   - 1.1. What are the infrastructure planning tasks in BRT planning process?
   - 1.2. What roles/responsibilities do stakeholders have in the planning tasks?
   - 1.3. How do stakeholders collaborate in the decision making process for infrastructure planning?
2. To understand BRT infrastructure planning process in Dar es Salaam
   - 2.1. What were the planning phases for Dar es Salaam BRT infrastructure planning?
   - 2.2. What were the roles/responsibilities of stakeholders in the planning tasks?
   - 2.3. How do stakeholders collaborate in the decision making process for infrastructure planning?
3. To design a conceptual collaborative SDSS framework for Dar es Salaam BRT, DART
   - 3.1. What are the spatial decision problems in BRT planning?
   - 3.2. What elements could make up a BRT SDSS?
   - 3.3. How would a group-SDSS for DART be structured?

1.4. The Conceptual Framework

A planning process is defined as "all activities, actions and decisions involved in a project's program or policy development from the initial concept through to operationalization" (Rizvi, pg 6, 2014). For this study, the BRT planning process is the flow of tasks/activities that need to be done by project stakeholders who make informed decisions to ensure that the actions taken for an activity produces optimal results for the project. Since the activities are interdependent of each other, the decision making process in turn has to be well coordinated among the project stakeholders.

Project stakeholders (Figure 2A), are defined as either individuals or organizations with skills, active roles, or interests in the project's execution or completion (Bal, Bryde, Fearon, & Ochieng, 2013). Depending on how the stakeholders collaborate in the decision making process (Figure 2B), expressed as stakeholders giving input that is reflected in discussion sessions with other stakeholders to generate alternatives, they can either ease the process of planning or present a barrier (Bal et al., 2013). This process of interaction among project stakeholders to produce informed decisions for a planning activity is where decision problems arise. This is whereby decision makers having multiple alternatives to a solution and faced with the task of selecting the optimal one that satisfies parties involved. They can be spatial or non-spatial, but for this studies to conceptually design a spatial decision support system SDSS, spatial decision problems are considered.

In the field of decision science (Figure 2C), SDSS tools have developed to aid in addressing decision problems, but for a successful application of a SDSS tool in BRT planning, a need for the tool has to be identified. The application design of the SDSS tool is informed by understanding the characteristics of the stakeholders, how they engage/collaborate with each other in the decision making process and the information needed for them to address a spatial decision problem. This information provides insight on the potential structure of a SDSS tools that fits and effectively supports a decision making process for an improved decision output for a specific planning task (Figure 2D).

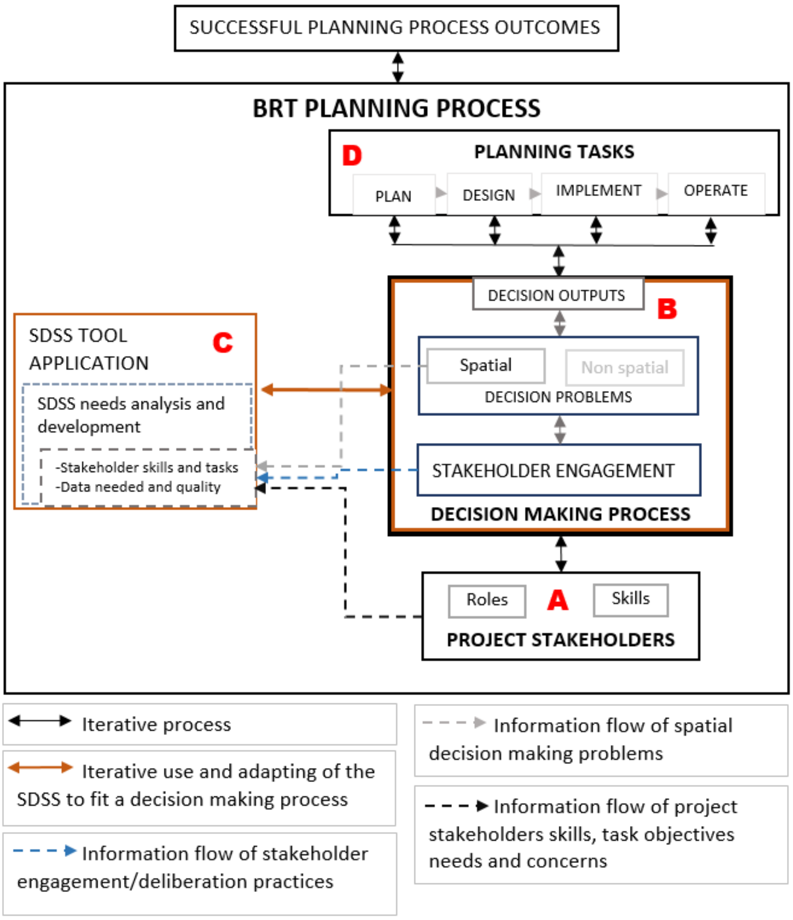


Figure 2 Conceptual framework

1.5. Thesis Outline

Chapter 1 introduces the research background and justification, the research problem, objectives and conceptual framework of the study.

Chapter 2 provides the literal overview of BRT planning models and SDSS structures in transportation planning to set the background information for the subsequent chapters.

Chapter 3 provides the in-depth review of the Institute for Transportation and Development Policy (ITDP) planning process model with focus on the planning tasks of stakeholder analysis, demand analysis for infrastructure selection, network design and system integration. The goal is to obtain insight on collaborative planning in BRT, potential decision problems and potential SDSS elements and application.

Chapter 4 discusses the BRT infrastructure planning process as practically applied in the model case of TransMilenio, Bogota to highlight how infrastructure planning activities were done and allow for practical case comparison of decision problems as well as strategies applied in addressing the decision problems. This chapter concludes with a reflection and summary of the spatial decision problems experienced

Chapter 5 describes the study's empirical research design. It outlines the, data collection process, process of data analysis and procedures for designing the conceptual SDSS framework

Chapter 6 describes Dar es Salaam's transport setting. The focus is on its road based public transportation to illustrate the conditions that made it opt for a BRT system.

Chapter 7 is the results and discussion chapter from the field work. This chapter describes the planning and decision making process with stakeholders as carried out in the DART project and concludes with the compilation of the spatial decision problems, inclusive of the earlier identified problems from the literal reviews of ITDP and TransMilenio.

Chapter 8 describes the potential structures for a BRT SDSS and presents a prototype application of a SDSS framework that could be used for the case of DART together with a critical reflection on the applicability of the prototype

Chapter 9 concludes the study with a summary of the answers to the research questions together with the study's recommendations for further research

Appendices contain the supplementary materials referenced in the thesis.

2. BRT PLANNING AND DECISION SUPPORT SYSTEMS

The BRT planning process is a course of tasks with specific activities that involves different actors. These actors deliberate in the decision making process over many feasible options to identify the most acceptable choice, leading to decision problems. This chapter provides a literature overview of the planning process as outlined by generic BRT planning guides and SDSS structures in transport planning. The aim is to understand BRT infrastructure planning tasks, stakeholder roles and responsibilities and existing decision making tools and strategies.

2.1. Overview of the BRT planning process

In BRT planning, there are different institutional models that are presented. These include the Institute for Transport and Development Policy (ITDP) model, German Technical Cooperation (GTZ) model and the Transportation Research Board model (TRB).

Figure 3 illustrates the ITDP model for BRT planning in which there are 63 detailed activities for the entire planning process. These activities are grouped into 20 sets of planning tasks that are categorized into 6 major phases. They include project preparation, operational design, physical design, system integration, business plan and implementation. This detailed ITDP structure resulted from the partnership of international transport consultants, with prior experiences in implementing BRT systems in the Latin cities of Curitiba (Brazil), Bogota (Colombia) and Quinto (Ecuador)(ITDP, 2007a; Lámbarry, Trujillo, & Rivas, 2013).

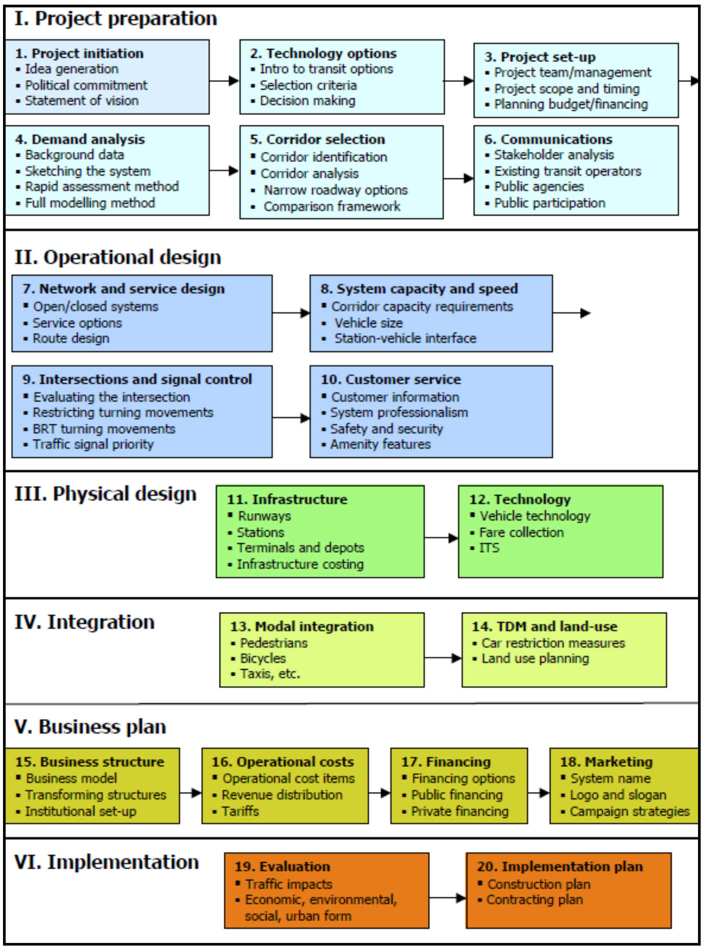


Figure 3 ITDP planning process
Source: ITDP, 2007

The GTZ model (Figure 4) described as a restructure of the ITDP model, has 46 detailed activities for the BRT planning process. These activities are grouped into 10 sets of planning tasks categorized into 4 stages; project preparation, design, impact and implementation. Its difference from the ITDP model comes from the inclusion of BRT experiences from emerging cases in other continents like Australia, Asia among others (Lámbarry et al., 2013; Levinson et al., 2003).

TRB planning model is a consolidation of best practises within the context of developed cities in the United States (Lámbarry et al., 2013; TRB, 2003). It comprises of 44 activities for the entire planning process that are categorized according to the main components of a BRT system. This is excluding the initial and final stage of planning and funding. The components of the model structure therefore include busways, traffic engineering, stations and infrastructure, BRT vehicles, intelligent transportation systems (ITSs), bus operations and service, funding and implementation (Figure 5).

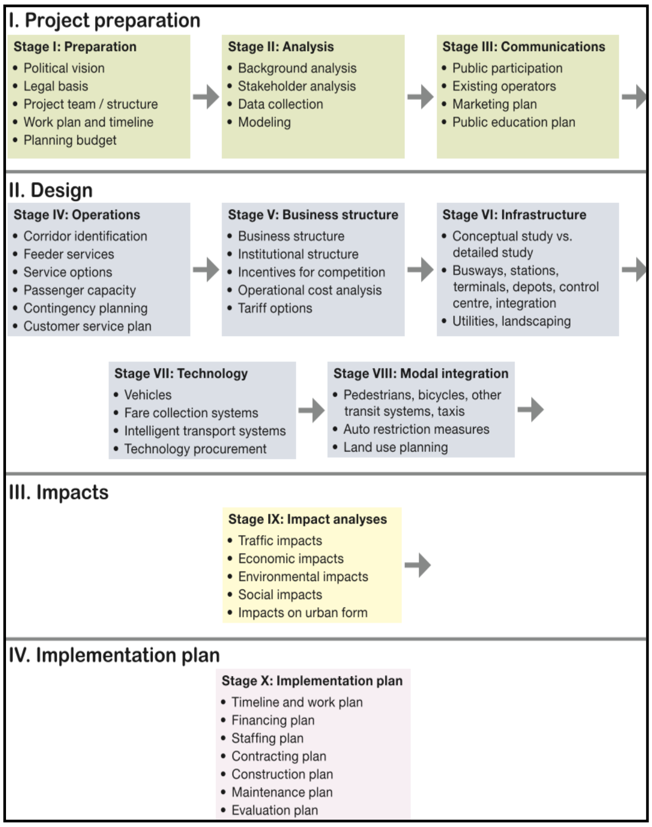


Figure 4 GTZ planning process
Source: Levinson et al. (2003)

For all three models, ITDP, GTZ, and TRB, the common acknowledgement is the need to involve multiple stakeholders from the transport sector in the planning process. (Lámbarry et al., 2013). These project stakeholders range from the public users, transport service providers to transport administrations.

The TRB model views community willingness to support public transport systems as an essential factor. A notion from the model is that if community willingness is extensively established and effectively managed it can facilitate implementation of BRT projects. (TRB, 2003). "A substantive public participation process in which ideas and recommendations are solicited from a range of citizens (e.g., public transport users, motorists) may be an effective means to a high quality design" (ITDP, 2007a, p. 3).

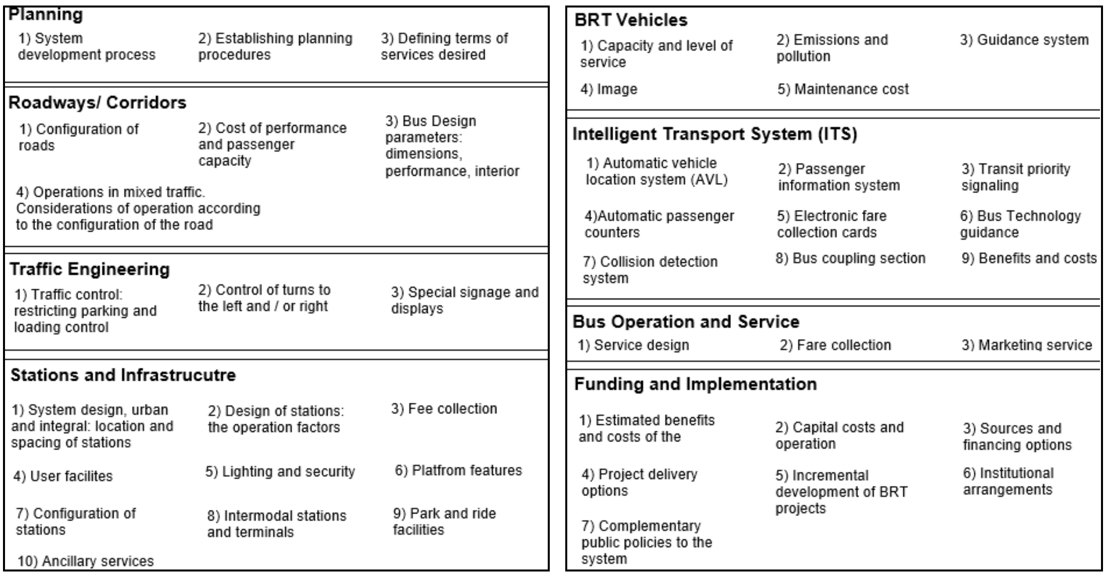


Figure 5 Planning process by TRB
Source: Adapted from Lámbarry et al. (2013)

A difference however, with the models in respect to stakeholder involvement, relates to the priority stakeholders the models identify. ITDP lays emphasis on building the political and informal bus paratransit operators will to establish the BRT system. The model's principle is that without the political will to actualize the BRT, coupled with resistance from bus paratransit transport operators to transform into formal companies favouring the BRT system, then the BRT technology is limited in its capacity to effectively transform the city into the desired environment (ITDP, 2007a).

An example of this is the BRT case for Lagos, Nigeria, which adapted the ITDP model. Many parts of the city have a public transport system characterised by heavy traffic congestion with unregulated number of paratransit vehicles known as danfos and okada. These vehicles function relatively lawlessly on the unsegregated lanes looking for customers. The Lagos State government identified this problem and the governor directed the development of a multimodal transport system that included a core road passenger transport network (Kumar, Zimmerman, & Agarwal, 2012). This led to the establishment of a politically insulated BRT lead agency known as Lagos Metropolitan Area Transport Authority (LAMATA). The lead agency had strong political backing from two consecutive administrations. This backing early on in the project protected the project against opposition by the taxi industry and other governmental agencies. Consequently, LAMATA was able to successfully coordinate and implement the BRT infrastructure investments for the city of Lagos (Kumar et al., 2012; Mobereola, 2009).

The TRB model on the other hand acknowledges the transit's property to operate across multiple administrative boundaries and hence the need to integrate the institutional arrangements of transportation systems (TRB, 2003). A principle within the model is that no single governance scheme is appropriate for transit planning for all areas. BRT elements should integrate with the entire range of transit elements provided in a region for the bigger picture as no city functions in isolation (TRB, 2003). Taking the case example of the city of Pittsburgh West, East and South busways. This busway was jointly developed by the Port Authority of Allegheny County, Pittsburgh Department of City Planning and the state of Pennsylvania Highway department (TRB, n.d.). The BRT lines link the city to other municipalities including Carnegie Borough in the far west and Swissvale to the east (Figure 6).

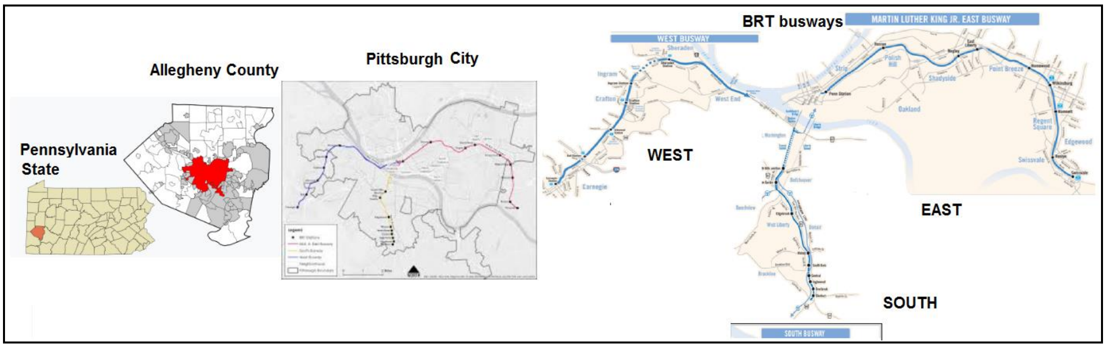


Figure 6 Jurisdiction boundaries for Pittsburgh BRT bus ways
Source: TRB and alleghenycounty.us website

In considering the structures of the models, there is a clear indication of the differences in the set up for the BRT planning process. TRB model focuses on establishing each BRT component with a vision that builds into the transit system. ITDP's structure is oriented towards establishing a form of business plan for transport service providers and urban rejuvenation efforts. Resultantly the ITDP model focuses on the planning phases of BRT that contain activities relating to the planning of a BRT component (Lámbarry et al., 2013).

Planners choice over which model to apply has been stated to be dependent on the nature of the existing public transport within the city planning to implement the BRT system (Lámbarry et al., 2013). For cities dominated with informal paratransit operators inclusive of minibuses, motorcycles (three and two wheel) taxis, and a political sphere that is attempting to address the shortfalls of public transportation, the ITDP model is commonly applied. Hence the model's appeal to most developing cities reacting to the transport problems experienced. For more anticipatory measures in areas where the transport systems are better structured, the TRB model is often selected.

Table 1 Differences in BRT planning models

Model	ITDP	TRB
Model structure	Detailed phase with activities related to BRT components	Focus is on the BRT components and their specific vision to a city's transit system
Application	Applied in Latin America and developing Cities	Applied in developed cities in United states
Stakeholders	Emphasis is on political will and paratransit cooperation	Emphasis on institutional agreements
Planning applied	Reactive approach	Proactive approach

Source: Adapted from Lámbarry et al. (2013)

Despite the differences (Table 1), common tasks in both BRT models include the preliminary activity of stakeholder identification, planning for BRT infrastructure, designing of the BRT elements and integrating of the system with other city functions (Lámbarry et al., 2013).

With this overview, and the study looking into the planning of the BRT system for the developing city of Dar es Salaam, the detail review of the ITDP model is relevant. This would allow for the comparisons of the theoretical planning and decision making process of BRT to real case scenarios. By understanding the generic expectations of stakeholders during the planning process and what is expected from them, potential planning activities that have spatial decision problems and the suggested tools and strategies used to address them can be identify. This in turn facilitates the development of a SDSS framework that fits to a planning task and contributes to answering the study's third objective. In view of this a review of SDSS structures is provided to better comprehend the subsequent chapters.

2.2. Overview of SDSS design structures

SDSS tools as earlier stated (see 1.1) are interactive computer based systems of information and analysis used in group decision making. These tools have become part of spatial planning activities since they provide planners with the capacity to improve the effectiveness of the decision-making process. This has included the ability to integrate different sources of information, and improve the provision of relevant information that can be quickly retrieved (Soo, Teodorovic, & Collura, 2006).

Zak (2010) describes transportation planning processes as multidimensional; with many actors to satisfy multi-criteria decision making and analysis (MCDA) has become a preferred methodology in decision making. MCDA tools allow decision makers to address decision problems which have different views that must be considered during deliberations. This makes them ideal for stakeholder settings. In addition, visualization of transport solutions like routes and locations on digitized maps has led to the emerging of geographic information system, for transportation, GIS-T. This concept incorporates GIS related task of digital mapping, and data management as well as more advanced application of GIS in data analysis and data presentation for transport related activities (Zak, 2010). The coupling of GIS and MCDA tools and techniques have given rise to multi-criteria spatial decision support system (MC-SDSS) tools. These tools have been developed with the expectations that in planning, they will offer mechanisms that describe the current conditions and allow stakeholders to generate alternatives and deliberate over the acceptable levels of risk (Bishop, 1998).

Coutinho-Rodrigues et al. (2011) have developed MCPUIS (Figure7), a prototype MC-SDSS system for analysing large scale urban infrastructure investment decisions. The prototype integrates GIS, database management (DBMS) and MCDA for a user friendly SDSS for decision makers. The GIS module supports spatial data storage, visualization and analysis functions. The DBMS stores and manipulates non spatial (alphanumeric) data while the MCDA performs distinct methods of additive weighting. The basic support function flow includes to store, retrieve and display data, evaluate investment options, compare and select investment option, communicate and perform a sensitivity analysis (Coutinho-Rodrigues, Simão, & Antunes, 2011).

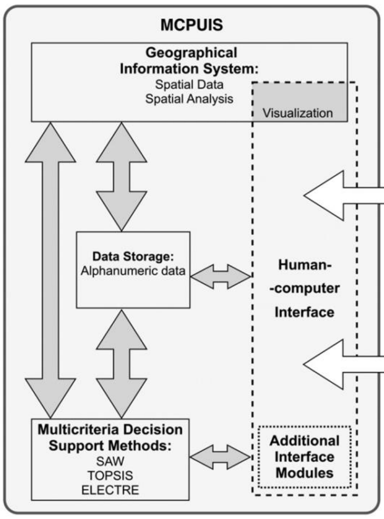


Figure 8 MCPUIS structure

Source: Coutinho-Rodrigues et al. (2011)

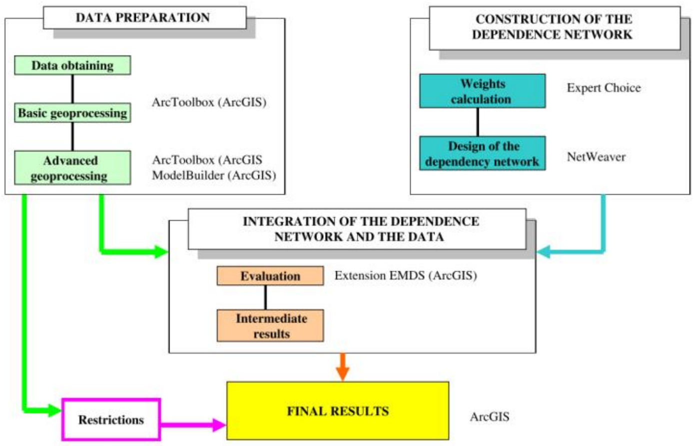


Figure 7 MC-SDSS for industrial site suitability study

Source: Ruiz, et al., (2012)

Ruiz, et al., (2012) describe a MC-SDSS for site planning tasks aimed at supporting strategic decision making that guarantees the viability of the industrial areas to their surroundings. Rationale for this structure's review is that the tool addresses site location of large infrastructures. In BRT planning, location of large infrastrucutres like depots and terminals transfer points are important to the system but their location should also not conflict with exisiting landuses. As such a tool strucutre that would help minimize such conflicts could be benficial to BRT planning. The MC-SDSS structure (Figure 8) incorporates the coupling of GIS to store and mange geographical data and Expert choice tools of Analytical Hierarchic Process (AHP) to assign weights to variables that define the multi criteria set. Resultantly the SDSS structure has three function modules that include data preparation, dependence network development and then integration of the dependence network with the data to obtain results on site viability. Within GIS, the weighted overlay tool is used to execute MCDA related task with assigned pre-set weights relating to the decision makers preferences (Ruiz et al., 2012).

AHP as a multi criteria decision analysis (MCDA) tool has been dominant in studies that deal with stakeholders or hierarchy among stakeholders and choices made (Soltani, Hewage, Reza, & Sadiq, 2015). The tool offers a systematic approach that supports decision makers to prioritise problems by managing decision criteria into a hierarchy. The uppermost level, defines the goal and objective, with subsequent levels comprising of criteria and sub criteria based on discussions made by decision makers (Chen, Yu, &

Khan, 2013; W. Wu, Gan, Cevallos, & Shen, 2011). The core of the AHP technique is the additive transformation function and pairwise comparison matrix (PCM)[1] which determines the weights to be assigned (Jankowski, 2007). A general concept is comparing the dominance between criteria as based on a judgment scale of 1-9 and the scores assigned are used to tabulate the matrix (Figure 9) (Chen et al., 2013; Jankowski, 2007).

IOI	Description
1	Equal importance
3	Moderate importance
5	Strong or essential importance
7	Very strong or demonstrated importance
9	Extreme importance
2, 4, 6, 8	Intermediate values
Reciprocals	Values for inverse comparison

CoC

	Criterion 1	Criterion 2	Criterion 3	Criterion 4
Criterion 1	1	2	4	3
Criterion 2	1/2	1	5	4
CoR Criterion 3	1/4	1/5	1	1/2
Criterion 4	1/3	1/4	2	1

Figure 9 Judgment scale of importance and pairwise comparison matrix

Source: Chen et al., 2013

Table 2 Average Random Consistency Index

Saaty's Chart	n	1	2	3	4	5	6	7	8	9	10
	RI	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49

Source:(Chandio, Iacsit, Nasir, & Matori, 2011)

$$CR = \text{Consistency Index (CI)} / \text{Random Consistency Index (RI)}$$
$$CI = (\lambda max - n) / (n - 1) \quad (1.1)$$

The advantage of AHP is in its capacity to factor in the imprecisions of perceptions from decision makers using a consistency ratio (CR) that should achieve a desired range of less than 0.1 (Eq 1.1). AHP offers those involved in decision making a flexible platform to adjust inputs provided. In insitiutions of limited resources, AHP can utilize basic spreadsheet files with a facilitator guiding the participants through the deliberation and readjusting of weights session. Stakeholders require no special skill to participate and the process is open computing that improves tranparency levels of the deliberation process (Chen et al., 2013).

MacHaris, Turcksin and Lebeau (2012) presented MAMCA, a multi actor multi criteria evaluation methodology for transport policy decision making (Figure 10). This SDSS evaluates transport alternatives based on the objectives of different stakeholders involved. Its initial steps are the identification of possible alternatives either through screening literature or early involvement of stakeholders, stakeholder analysis to identify the relevant project stakeholders, and the assigning of weights to key stakeholders' objectives. Indicators are then established for each criterion and a MCDA applied which translates alternatives to scenarios. The scenarios can be scored and ranked to reveal strengths and weaknesses of a scenario and the stability of the ranking further tested using sensitivity analysis (MacHaris et al., 2012).

[1] PCM: If CoC is compared to factor CoR, and factor CoC is assigned one of the dominance scale numbers (1-9), then factor CoR is be assigned the reciprocal value of CoC (i.e. 1/(value for CoC).

[2] The random consistency index is obtained from Saaty's chart depending on the matrix size (n) and the Principal Eigen2 value (λ max) which is the average value of the consistency vector. λ max: multiply the sum of products between each element of the priority vector by the sum of columns of the reciprocal matrix the average value of the consistency vector).

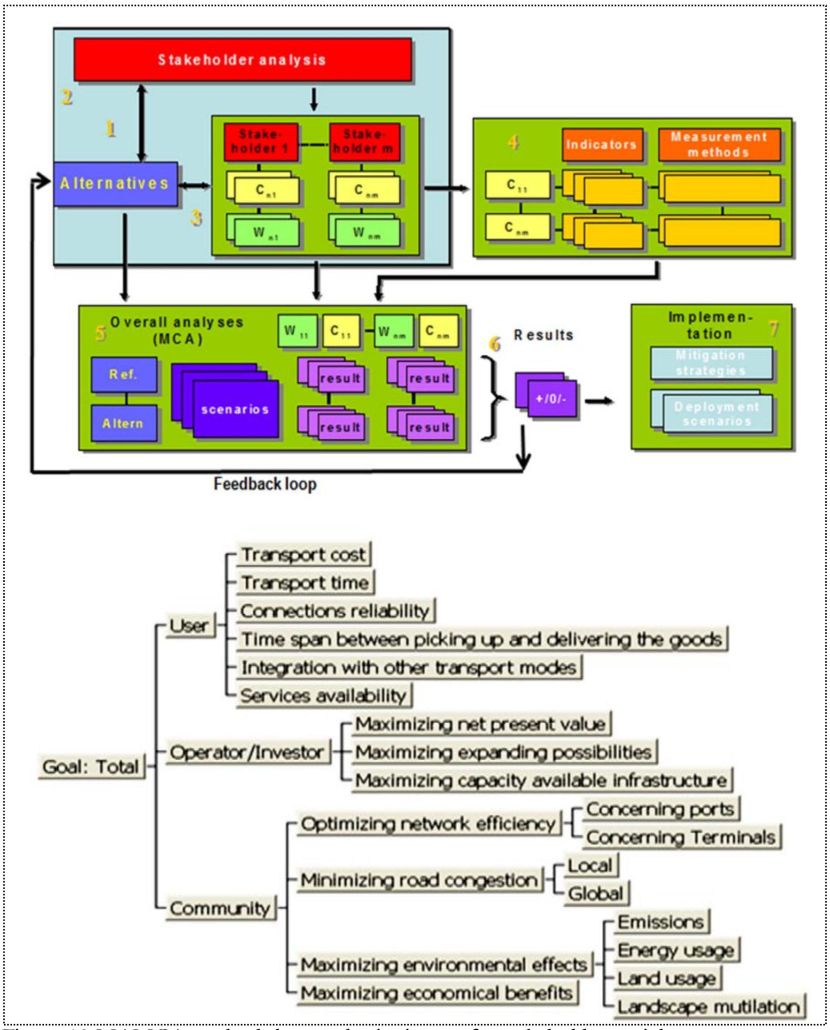


Figure 10 MAMCA methodology and criteria tree for stakeholder weights

GIS-MCDA/MC-SDSS tools have developed with a view that allowing stakeholders to deliberate on the information provided, communicate their concerns and generate alternatives builds understanding of the differences in perspectives. This makes the transport projects inclusive. To manage this information, Mota, de Almeida, & Alencar (2009) acknowledges the importance of supporting project leaders. The rationale provided is that by supporting the project leaders, in managing the information and decision making process with stakeholders using MCDA, the process of planning would maintain focus on the main tasks for a project.

2.3. Summary of BRT and SDSS overview

In BRT planning, the application of a planning model depends on the existing conditions of the city where a BRT system is to be implemented. Planners in developing cities tend to opt for the ITDP model approach in attempts to counter the paratransit transport systems, while developed cities mainly in USA utilize the TRB model approach. But as much as the planning process's structures, principles and application locality may differ, fundamental activities for infrastructure planning include stakeholder identification, planning for BRT infrastructure, design of the BRT elements and integration of the system. From both models, infrastructures that should be provided in BRT planning include the corridors of a reasonable network to have an impact on existing transport services and stations (trunk stations, feeder stations, terminal, and depots) that should be strategically located along the routes to attract and maintain ridership for the BRT system.

As an approach for transport planners to manage the planning process with stakeholders, SDSS structures provide a platform via multi criteria analysis using AHP tools and GIS software. A combined application helps improve transparency and ease in communicating spatial issues of the project.

This overview guides the development of the subsequent chapters in highlighting the specific infrastructure planning tasks, collaborative decision making process, the decision problems experienced, in addition to the tools available for decision making.

3. A GENERIC BRT PLANNING INFRASTRUCTURE PLANNING PROCESS

3.1. ITDP Planning Process

3.1.1. Project preparation

As the initial stage of the BRT planning process, project preparation activities include the setting up of the projects vision for the city and the team that facilitates the planning of the BRT system. This stage entails the process of stakeholder analysis, demand analysis and corridor selection. These processes are considered fundamental to the planning process since they form the basis on which most, if not all other subsequent activities in the planning process rely on (ITDP, 2007a).

The vision of the BRT to the city, though non-spatial in nature, is important to the planning process because it describes the physical, social and economic environments that the BRT system is to help establish or rejuvenate. This in turn guides the objectives of the activities to be undertaken in the planning process. The vision also influences the decisions made by project stakeholders during deliberations in the decision making process. Therefore, the team established as the lead agency must be competent enough to facilitate the relevant tasks and stakeholders needed to actualize the set vision (ITDP, 2007a).

3.1.1.1. Stakeholder Analysis

Stakeholder analysis in BRT project preparation is done to identify the project stakeholder groups with the skills, information, or interests that facilitate the execution of a planning activity. This also includes those with concerns and problems, who might present a barrier (Bal et al., 2013; ITDP, 2007a). By understanding the project stakeholders, the decision problems that arise during decision making for a planning activity can be better understood. Consequently, effective collaboration strategies can be established that address stakeholder concerns and facilitate participation.

The ITDP model as an initial step of stakeholder analysis categorizes public transport stakeholders as either public targets or private targets. This is an approach to manage the information obtained from stakeholders about the stakeholders and to design effective communication strategies for them (ITDP, 2007a). Public targets are the transport users and the general population, while private targets are those actively involved in the planning task by either providing a skill or regulation for the transport system. Important private target stakeholders include the internal project team, government agencies, local authorities and the existing public transport service providers (ITDP, 2007a). Irrespective of the category, communication strategies for all project stakeholders must be well defined and regular to avoid opposition building up and delaying the project at later stages.

Initial communication structures for a BRT project involves setting up communication channels and practises for the lead agency. These should be well defined before the team begins to manage participation activities with different stakeholders. Collaboration among the teams and the specific planning activities should utilize regular progress review sessions to provide updates on the current status, changes and challenges experienced in the planning process. These sessions also help the team to critically generate and review plans for further activities and ensures team leaders communicate aligned information to other stakeholders (ITDP, 2007a). Break down in the teams' communication protocols or dissemination of contradictory information from deliberation sessions can lead to doubts. This makes the planning process vulnerable to mistrust by stakeholders and an opportunity for the opposition to rise against the BRT project.

Effective communication by the lead agency with government institutions, ministerial or local authorities' level, is critical in securing political support. Presenting a comprehensive BRT system for a city to both the party in power and the opposition, improves the opportunity of the BRT projects to be incorporated into the city's development plans (ITDP, 2007a). This however depends on the existing political climate. In the case of Jakarta's BRT, TransJakarta, initial plans started as back as the early 1990 before its implementation plans proposed again in 2003. Earlier on, World Bank had financed an engineering design of a median busway and a complementary review of the public transport network planning for Jarkarta. However, the national and city governments implemented cheap and quick busways, along the roads with no considerations of prioritizing the bus operations. Resultantly the project failed and its reintroduction by the governor in 2003 met by scepticism (Kumar et al., 2012). For cases in most developing African cities, a challenge to BRT projects strategy in which opposition parties are approached might not be of much assistance to a project. This is viewed from the stand point of the dictatorship form of rule and long standing regimes in the political settings of most African states. If the concept of BRT is presented during a dictatorial regime that is against it, its chances of actualization are low irrespective of the opposition's support for the project.

For the existing transport operators, project information is shared with them to dismiss concerns that might lead to them resisting the BRT project. A major challenge to the lead agency in engaging the operators is in identifying the paratransit service providers, because the operators lack proper organisation (ITDP, 2007a). This makes it necessary for lead agencies, local authorities and existing transport institutions formal and informal to collaborate in identifying the actors (drivers, bus owner, and transport company's administrators). The constant attending of interest group meetings, union assemblies, as well as holding discussions with the transportation operators and transport company officials is necessary (ITDP, 2007a). Schalekamp & Behrens (2013) identify for the city of Cape Town, an estimated 7500 licenced vehicles that operate on 565 city routes with around 6400 owners, with more than 100 operator associations. And if the unlicensed paratransit fleets were considered, the vehicle numbers rise to approximately 12500 operators. This illustrates that indeed engaging the paratransit operators is a complicated task and it can be dissuading to planners and decision makers from being time consuming. The process of deliberating with paratransit representatives in Cape Town for the MyCiTi BRT system took around four years to establish three BRT operating companies, out of eight shortlisted paratransit associations, and two bus operating companies (Schalekamp & Behrens, 2013).

As a management strategy from the magnitude of the paratransit operators, engagements within stakeholder sessions tend to be limited to associations rather than the individual operators. This practice has been applied under the assumption that the manageable size of the association is representative of the attitudes of the operators within the association (Schalekamp & Behrens, 2013). Reservations however, have been expressed regarding the sustainability of this management strategy. The concerns have been that owners should be initially investigated for long term solutions as they have more to offer than groups at an association level (Ferro & Behrens, 2015; Schalekamp & Behrens, 2013). But this would require resources which for developing cities, might be a challenge.

Common BRT mechanisms and tools utilised in stakeholder participation include town hall meetings, or polling system via website or post. Town hall meetings if well-organized enable a wider range of stakeholders to participate. But common limitations have been the failure of participants to make time to attend the meetings, especially if the location of the town hall meetings are relatively out of stakeholder access. Website polling systems offer solutions to challenges of town halls as they enable the stakeholder to participate from anywhere as long as they can access the website and follow the set procedures. This however requires the respondent to have some basic knowledge of computer skills, in addition to access stable internet network and electricity supply to keep the website running during the participation session. In some developing countries, power rationing practices are common and might limit the use of internet for deliberation.

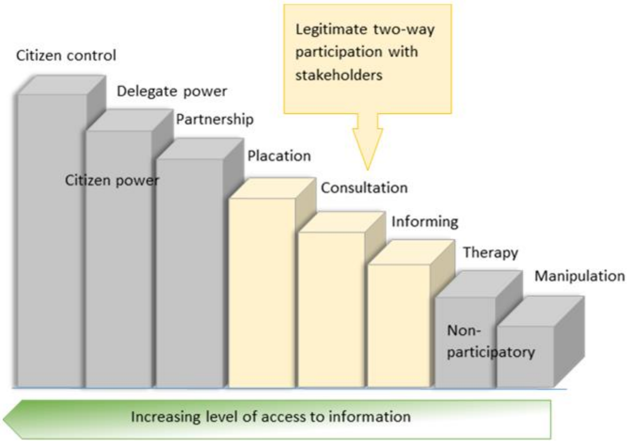


Figure 11 Arnstein's ladder of participation highlighting focus of the study

Source: Adapted from Arnstein, 1969

Focus group settings are considered productive tools especially when a skilled facilitator is used to gather in depth stakeholder views concerns and solutions in the planning process (ITDP, 2007a). The choice of the tool used often depends on the characteristics of the stakeholders and the information that is needed or needs to be conveyed. As Cascetta et al, (pp 28, 2015) points out, "Planning and designing transportation systems should expressly be recognized as managing complex, multi-agent decision-making processes in which political, technical and communication abilities should all be involved in order to design solutions which are technically consistent and, at the same time, maximize stakeholder consensus." Stakeholder engagement/participation for this study is described as meaningful communication that incorporates stakeholder concerns and needs with the visions of decision makers and planners. This helps to establish a process that reflects transparency and greater stakeholder input that builds support for a planning outcome (Cascetta et al., 2015; OECD, 2015).

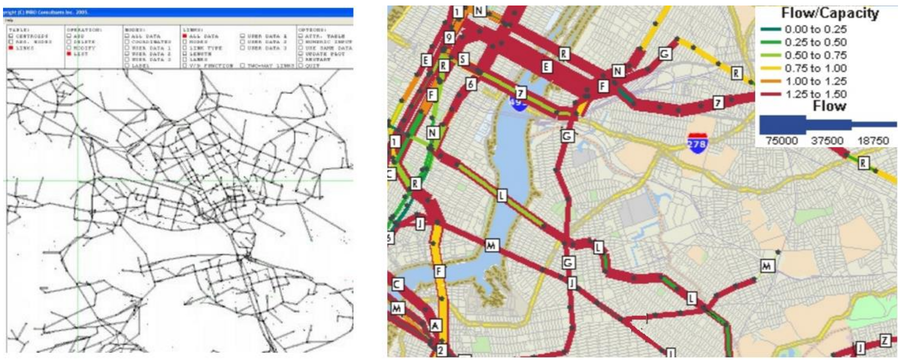
In reference to Arnstein's (1969) ladder of participation (Figure11), stakeholder engagement/participation described for this study fits within the third to fifth level. As an initial step, stakeholders are informed about the project and have the opportunity to provide input during the planning process. The stakeholder inputs are considered and incorporated by planners and decision makers and are presented for deliberation during progress evaluation sessions. This describes the consultation process in the decision making process. Placation then follows where the possibilities of objections by the stakeholders over the decision output or project outcome are reduced. Usually the process of stakeholder engagement in BRT is applied in the initial stage of the project, to seek out views on potential problem-cause factors (ITDP, 2007b).

3.1.1.2. Demand analysis

Demand analysis is a data intensive process that provides an evidence based approach to decision making for the BRT infrastructure selection and development activities. However, in real practise, this process is often compromised by the top down approach of decision makers in planning (ITDP, 2007a). This approach tends to be applied in most transit infrastructure planning efforts, and BRT infrastructure is no exception. Infrastructure developments have been selected based on either a political or technical statement by top decision makers who are mainly from government institutions. In Peru, a rail corridor selection was made by the president which resulted into a high cost infrastructure "Tren electrico" being built in a low demand area. With time, revised passenger estimates were done for the project and the results indicated that the project was not beneficial when compared to the investments being put in. This consequently lead to its construction being stopped (Menckhoff, 2002 as cited in ITDP, 2007a).

BRT systems have been located on wide roads because there was space, but little demand or corridors set up per district for political reasons and in disregard of the corridor's service to riders (ITDP, 2007a). For an evidence based approach to decision-making, demand analysis is important because it provides a justifiable basis for designing the BRT system and its related infrastructure components (ITDP, 2007a). Demand analysis helps planners to understand the size of public transport usage along existing roads and the geographical location of the users' origin and destination points. Such information is used by planners to link the system to the transport needs of the user for optimal service. To obtain the demand information, planners and experts utilize transport demand software tools. The common tools include Emme/2, Arc/Info and TransCAD (ITDP, 2007a).

Emme/2 is a reputable software tool for multimodal transportation with the ability to automate the four-step model for traffic analysis that can be generated under different conditions (Li, Zou, & Levinson, 2004). Its limitations however arise from a poor graphical interface and its requirements for the network maps in Emme/2 format that are difficult to obtain. To address this shortfall, modelling experts tend to combine the Emme/2 with the GIS software of Arc/Info. An advantage of GIS is that for most institutions with spatial related data, GIS formats are commonly used and this makes them readily available. GIS enables different data obtained from different agencies to be integrated for different purposes. In addition, GIS software are powerful tools in data management, analysis and have a user friendly graphic display interface. As a results some modellers use TransCAD which has developed as an integration of the other two softwares (Li et al., 2004). TransCAD provides an easy to understand interface for transport information (Figure 12).



Emme/2 interface **TransCAD interface**

Figure 12 Interface differences between Emme/2 and TransCAD

Source: Traffic analysis forum and TransCAD websites respectively

The four step traffic models are highly accurate, and form the basis for the application of transport model software products. However, they are time consuming and expensive. An alternative is the rapid assessment techniques that produces demand estimates of acceptable accuracy quickly and at relatively low cost (ITDP, 2007a).

Irrespective of the technique used, the demand modelling process remains data intensive. It requires the cooperation of the traffic departments, general public, trained personnel and local consultants to effectively conduct the traffic survey studies. International consultants/experts use the traffic survey information to build a city's travel demand model. The data required includes basic travel information on the current transit services routes, passengers per route and the transit vehicle speeds on each route which can be obtained from municipal offices or transport regulations authorities. In cases where paratransit's dominate, with weak regulations, mapping of existing routes structure for buses is a necessary activity (ITDP, 2007a). This activity can be used by existing authorities as an initial step to building its transport information database and gaining control over the unregulated fleets in service. The information generated can be used to identify areas of high paratransit activities and those of low services. Through a well-informed approach transport authorities regulate the permits administered.

Demand analysis should also identify congested points along corridors on the notion that BRT corridor on congested routes encourages modal shift from private car to public transport use (ITDP, 2007a). Once demand is determined, decision matrix criteria relating demand to BRT service options is utilised to facilitate further deliberations on the corridor type (Figure 13). This part of the process is where decision problems are likely to occur.

Transit passengers per hour per direction	Type of BRT solution
Less than 2,000	Simple bus priority, normally without physical segregation, possible part-time bus lane
2,000 to 8,000	Segregated median busway used by direct services reducing the need to transfer
8,000 to 15,000	Segregated median busway used by trunk services requiring transfers but benefiting from fast boarding and operating speeds. Transit priority at intersections.
15,000 to 45,000	Segregated median busway, with overtaking at stops; possible use of express and stopping services. Use of grade separation at some intersections and some form of signal priority at others.
Over 45,000	This level of demand is very rare on existing bus systems. It is possible, however, to design a BRT system that would serve up to even 50,000 passengers per hour per direction. This can be achieved with full segregation, double busway, a high proportion of express services and multiple stops. This capacity could also be handled by spreading the load through two or more close corridors.

Figure 13 BRT service options depending on demand analysis results
Source: ITDP 2007a

Stakeholders with higher ethical and social considerations in deliberations would like to see the social justice of the project. Using geographical information systems (GIS) social-economic and environmental data can be integrated with transport data to identify vulnerable areas (ITDP, 2007a). Information on existing demographic figures, social equity levels within districts, economic activity by social groupings, employment levels, can be obtained from municipalities, NGOs, or the statistics agency. When presented to decision makers and other stakeholders during decision making, areas in need of urgent investments can be favoured in the decision outputs (ITDP, 2007a).

However, the most dominant considerations by decision-makers in BRT infrastructure planning tends to be the ease of implementation, political factors and the systems economic cost (ITDP, 2007a). Since BRT's are promoted as low cost infrastructures, major decision problems arise when trade-offs need to be made between the possible network extent and infrastructure costs from the coverage (Wu & Pojani, 2016).

3.1.1.3. Corridor selection

For public transport users, an extensive corridor network serving major origin and destination points is preferred when compared to a system of few kilometres. The latter is associated with being relatively limiting and inconvenient in services offered. From the perspective of BRT planners, an extensive coverage secures passenger usability and offers greater likelihood of decreasing the continued use of private cars. This supports the realization of goals and survival of the BRT system (ITDP, 2007a). An extensive coverage network however, would increase the cost of the BRT infrastructure from relevant government budgets with increase in land and property acquisition costs along the corridors (Satiennam & Fukuda, 2006). This can further lead to conflicts and delays in negotiations, dissuading the project funding or public support.

Generally spatial implications associated with planning for urban infrastructures are wicked in nature. Their evaluations have to consider multiple and conflicting criteria of importance placed on them by stakeholders. This process of evaluation therefore needs to be adequate (Coutinho-Rodrigues et al., 2011). In BRT infrastructure planning multi criteria analysis provides an analytic framework that can be utilized to address spatial decision problems. Cost benefit analysis as an approach can quantify benefits from factors like time or fuel saving or environmental improvements. If the practise is well facilitated it helps stakeholders understand alternatives and make better decisions (ITDP, 2007a) .

3.1.2. Designing a network

The operational and physical design phases of the BRT system involves the development of technical specifications for the projects infrastructure. It details the plans for the infrastructure, modal integration, technology and costs, as guided by the results of the demand study (ITDP, 2007a). A conceptual study of the project is usually done to ensure decisions made are cost effective. This involves the identification of factors that will lead to an optimal BRT system performance especially at the initial project phase for mass transit operations. Success of the initial corridor is critical in illustrating the potential of BRT to a city and can influence further support for the project (ITDP, 2007a). In reference to the earlier example of Trans Jakarta (see 3.1.1.1), scepticism was reduced with the revived BRT corridor operations implemented in 2004. Proper operations and infrastructure plans that were adhered to had an almost immediate appreciation from the transport users over improved public transport services. As a result, there was increased support and demand for more extensive networks. Within a time frame of three years, six additional corridors were developed and operational in Jarakta (Kumar et al., 2012).

The general principle in BRT design, is the establishment of a rapid, high-capacity operation system of BRT elements that supports efficient passenger and vehicle movements (ITDP 2007a). Hence high density areas identified from the demand analysis are considered as prime selection sites for high-volume, high-capacity infrastructure operations, while lower-density areas fall into lower infrastructure services. Resultantly, trunk/main BRT corridors are located on main roads where demand tends to be high and feeders on routes with low demand (Ferro & Behrens, 2015).

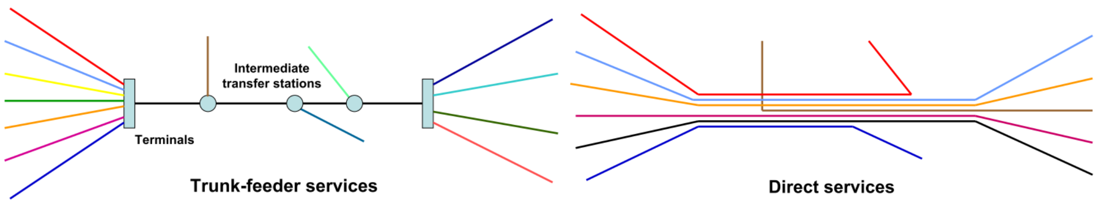


Figure 14 Design options of corridors services
Sources ITDP 2007a

Decision problems in design are exhibited when existing transport operators, planners and relevant authorities have to generate relocation alternatives that the operators are willing to accept for the BRT project to move forward (Ferro & Behrens, 2015). Routes affected by the trunk corridor selection requires operators to either terminate their operations or relocate to other transport corridors. Relocation areas might not be attractive either due to reduced profits from ridership, poor infrastructure or over supply of relocated operators leading to traffic problems along those areas.

In other instances, public transport users who had direct service lines can disapprove of transfer points that require the use of feeder services running in mixed traffic for them to move from residential zones to transfer stations or terminals to reach their destination (Figure 14). Preference is usually for direct trunk lanes and services. But direct trunk routes for the BRT system would require, either long station platform or multiple platforms to accommodate the vehicles (ITDP, 2007a). This not only increase the infrastructure cost but also the amount of space needed that could be a problem for planners and decision makers. The needed space may impact on the right of way allocated for other road users in mixed traffic or pedestrian and bicycle lanes.

For BRT transfer points, designs on locations and spacing of conventional stations (stations used by trunk services), feeder stations (stations integrating with feeder routes and terminals stations) terminals and depots should ensure passengers have accessibility to the stations. Accessibility is defined as the ability for transport users to reach stations with minimum obstruction (ITDP, 2007a). Common decision criterion has been the location of stations near popular destination areas such as commercial complexes, educational centres, or main junctions based on intuitive local knowledge to reduce walking times.

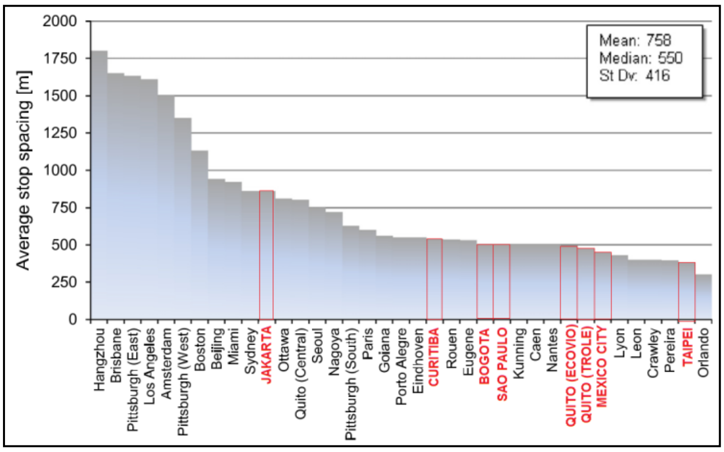


Figure 15 Stop spacing for BRT systems around the world
Source: (Tirachini, 2014)

In cases where an objective approach is applied, planners generally locate stops on an average distance of no more than 300m apart within the city center and between 300 to 500 metres in between conventional stations for areas outside the city center. It is noted however, that maters of station locations are specific to the city in which the BRT is developed (Figure 15). BRT systems can have average stop spacing's of 758m over a wide range of values; from 300 to 1800 m (Tirachini, 2014).

A recommended approach for optimal location of stations considers user demand. It is data intensive and uses studies on passenger boarding and alighting movements to helps identify areas of high passenger mobility. For such areas frequent stops sites and bigger station platforms offer better services. Areas with low boarding and alighting passengers, have greater distances set in-between stops and can manage small size stations (ITDP, 2007a). Despite the importance of station location in respect to demand, and the impact it has on spatial dimension of the station, issues of stop design and spacing have been more concerned with the station's physical appearance, platform vehicle interface, lighting systems, passenger safety, and accessibility for the disabled (Tirachini, 2014). This study considers this a limiting factor to optimizing of BRT systems.

Terminals are considered key transfer points and tend to be located at the end of the trunk corridors. A key design consideration is fluid movement of people and tuning vehicles. Hence they require large amounts of space to ensure traffic congestion of the trunk and feeder buses are avoided. In addition, terminals must have considerations for additional services in the form of potential business areas and depot space (ITDP, 2007a). The rationale for designing depots adjacent to terminals is the need to reduce or avoids dead kilometres. Dead kilometres is the distance covered when the bus is out of service and returning to the depot parking during off-peak times, or from depot to a terminal to resume service during peak sessions. Since in BRT service providers are paid per kilometre of service offered, dead kilometres may lead to operation costs that might deter service providers (ITDP, 2007a). But to existing land uses in a city, the amount of space needed for such investments tend to be lacking and is often a source of conflict.

Most of the infrastructures designed for BRT tend to affect the right of way sections of the roads which affects utility infrastructures like water, sewerage, cable or electricity lines that are usually concentrated along these sections (ITDP, 2007a). Deliberation on either relocation or compensation matters with utility companies is hence important at this stage. Planners and consultants can utilize city utility maps from the relevant utility companies to ensure the construction for BRT infrastructure does not damage the utility lines. Drainage along the corridor should also be designed such that the BRT lanes do not spill over or interfere with drainage for mixed traffic lanes. Use of hydrological models and hydrology experts can be utilized to provide input on proper drainage system options.

Based on the inputs from the previous activities of demand modelling and the operational and physical design activities, an initial designs of the various infrastructure elements can be conceptualized. Using visual illustrations the system can be communicated by planners to a range of stakeholders. Simulation videos that give relatively realistic ideas to the decision makers and stakeholders over what to expect are good tools of communication that can influence support for the project (ITDP, 2007a).

3.1.3. System Integration

After visualizing how the system could look like it is important to see also how it will function in relation to other transport systems. The principle in system integration is that BRT should not be planned in isolation but in view of it being a complementary system (ITDP, 2007a). System integration ensures that the BRT busways (trunk and feeder), stations, terminals and depots are well linked to each other and with the existing walkways, bicycle lanes or rail system, in addition to the functions in a city. Since stations (conventional stations, feeder stations, terminals and depots) are defined as linkage points, their evaluation in system integration is important (ITDP, 2007a).

Evaluation criteria for the systems integration in terms of accessibility, directness and connectivity helps in deciding how best to design the BRT infrastructure (ITDP, 2007a). Ease of accessibility describes the simplicity in using the system in relation to potential barriers like topography, weather incidences, or route surfaces conditions. Directness refers to the minimal path pedestrians cover to utilize public transport facilities while connectivity looks at the broad network that is made available for the users (ITDP, 2007a).

Pedestrian counts and pedestrian movements are important activities for understanding issues around station. Planners can organize walking origin-destination (O-D) studies and tracking surveys that provide the baseline data utilized in identifying optimal designs for an integrated pedestrian infrastructure (ITDP, 2007a). Understanding passenger concerns and solutions regarding pedestrian ways, to and from stations, can help planners secure ridership for the BRT system. Planners can use spreadsheet programs for visual identification and recording of good quality footpaths, crossing facilities and obstruction points to rank suitability of a BRT's station accessibility. More GIS related approach can be facilitated by advanced technology tools in tracking apps like GPS for basic community perception mapping of streets to understand their experiences in accessing BRT transfer points (ITDP, 2007a). For cars, motorbikes or bicycles, park and ride facilities are key in integrating the systems. While the facilities need to be located at popular stations, the benefits of this must be weighed against the benefits of transit oriented development, TOD activities that could include business plazas or cultural centres(ITDP, 2007a). This is a potential source of decision problems

3.1.4. Business Plan

While not considered in detail for this study, activities relate to BRT infrastructure investments and the restructured management of the public transport that improves quality of the service provided. Other activities include setting up of the operational costs, managing finances from municipal and national funding and marketing of the BRT concept (ITDP, 2007a).

3.1.5. Implementation

As the final stage of the planning process, it entails the formal preparation for construction outlining the procedures for traffic management and redirecting during construction or compensation by contractors, which indicates that the planning process was sufficiently done to warrant a full implementation (ITDP, 2007a).

3.2. BRT Decision making process

The ITDP BRT planning process model outlines detailed tasks that need to be done for BRT infrastructure development. The decision making process it defines relates to technology selection. It defines the process as objectively evaluating public transportation options presented and narrowing them down through sound analysis (Figure 16).

Figure 16 Decision making process for technology selection
Source: ITDP 2007a

For stakeholder engagement in the decision making process, the model mostly identifies the stakeholders who need to participate in decision making for a task and the results expected if they participate or not. It however fails to guide on how collaboration with stakeholders in the planning process is or could be done. In recognition of this Vilchis, Tovar, & Flores (2012) provide a theoretical model for decision making with stakeholders for consensus building in BRT planning (Figure 17).

The ITDP model through stakeholder analysis, relatively describes the three initial stages of assessing interested parties who agree to participate in the planning practise and whose responsibilities and communication strategies are defined (Figure17A). The decision making rules, however, are not clearly defined as well as the process of deliberation, decision making itself or how alternatives from stakeholders are to be handled.

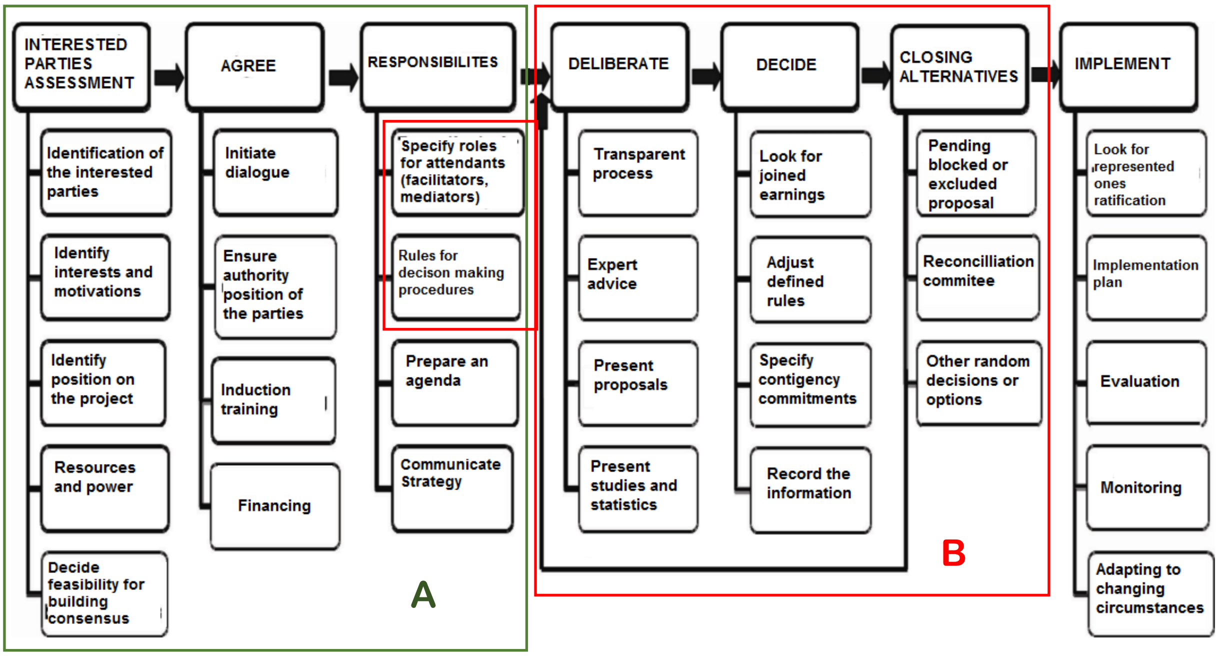


Figure 17 BRT decision making process for consensus buildings
Source: Vilchis, Tovar, & Flores (2012)

Deliberation involves the combination of technical studies, statistics, and expert advice the deliberating project stakeholders utilise during discussion sessions (Vilchis et al., 2012). The deciding process makes use of a mediator who prepares a draft agreement to be presented to the project stakeholders for suggesting improvements that seek to maximise on consensus. Each participant is kept informed of the debating process and the thresholds for votes. Closing alternatives aids in forecasting of alternatives that limit the process that need to be deliberated on again or need special intervention via a reconciliation committee (Figure 17B) (Vilchis et al., 2012).

In summary, the strength in the BRT planning process is that the activities are not only about providing BRT related infrastructure but the planning for the functioning of a system. Activities that go into planning for BRT systems must include the BRT elements, the system performance and the system benefits functioning as a unit (Figure 14). A detailed look into the BRT system is provided in Annex 1. As a result all other activities must be well coordinated to ensure optimal BRT systems are set up.

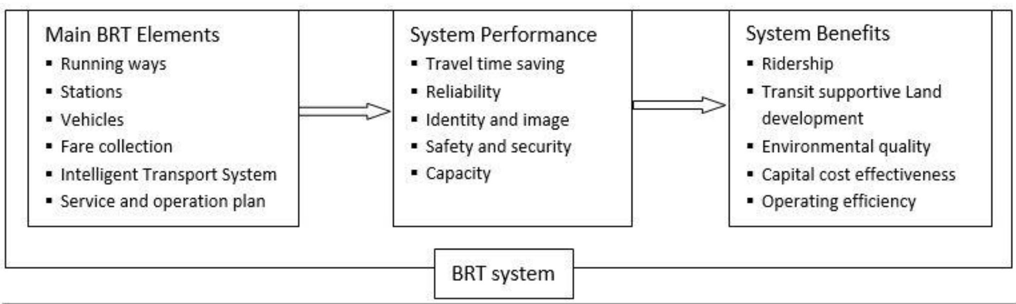


Figure 18 BRT system set up
Source: Adapted from Wright, 2003

3.3. Reflection of BRT Planning Process

The ITDP model is detailed in what should be done in the planning phases. Project preparation by setting up a vision that guides the project is a strategy the study appreciates. However, the models structure in the form of a business plan limits the potential of reshaping the society in general for an improved transport setting. By using the transport users together with the transport service providers to define the vision of the transport sector, the objectives within the planning process might be better guided to restructure the sector based on the needs of the city and not a particular group. Indeed it is challenging to gather and balance the opinions of the paratransit group together with the public users. But by making the public responsible for their transport needs, the potential of restructuring the paratransit systems might fall into place.

In developing Africa cities, where motorization is increasing with the increase in income levels and deteriorating public service, walkways and bicycle lanes for the public and an attitude change of the latter modes as poor-people travel modes has the potential to make BRT systems function better. By having the public generate the vision of the city's cycle and walking plans, and this information can be used together with demand analysis information for improved BRT integration designs. This can make use of the current tech survey generation to foster future behavioural changes in transport.

Political support for any project is beneficial. This is especially so if a concept is new and it is to address a relatively complex setting like transport restructuring with multi-dimensional stakeholders. The concerns of ITDP model's emphasis on securing political will, is that it makes the project relatively prone to political manipulation. Therefore, as much as political will and "political insulation" is needed to be secure the project against political opposition, legislative structures established for the BRT agency should also be established that are strong enough to protect it against political manipulation. This increases the extent in which other stakeholders are involved in the planning process.

Demand analysis data is important in the planning process and their use in supporting decisions made means they need to be well facilitated. Actors responsible for the data collection should be well trained to avoid inaccurate information. This might lead to a waste of limited resources or failure of the initial phase of the BRT project leading to waning support. An important note however is that the demand model outputs are used to guide and improve decisions made they are not meant to dictate what the decision should be. The same notion is applied for any tool applied in the decision making process.

Tools include transport planning software's and GIS that provide objective approaches in planning as well as channels that allow visual interpretation of information. These tools should be structured in ways that they do not manipulate stakeholders into decisions. Minimum thresholds and standardizing procedures guiding how the stakeholders, tools and task objectives actually interact need to be defined. No planning process is the same but an acceptable minimum allows for a base from which to build on.

Spatial decision problems in the planning tasks that could be expected in BRT planning process are summarized in table 2.

Table 3 Summary of expected decision problems from BRT planning process

Planning task	Spatial Decision problem	Stakeholders	Decision making tools and strategies
Corridor selection	***Selection of type of BRT solution-*** ▪ part time bus lanes without physical segregation, ▪ segregated median busway with double bus lanes at overtaking stops, ▪ full segregated double busways with one or two other close supporting corridors ▪ Trunk-feeder or direct service lanes	Lead agency planners, government officials, local authority representatives, transport authorities ,traffic police department, international BRT experts, transport demand modelling consultants, local transport operators, general public	-Transport OD demand modelling -GIS maps , social data, -Cost benefit analysis(MCDA)

	(Relocate or cancel routes)		
Network coverage extent	***Selection of BRT characteristic*** ▪ Limited pilot coverage along major trunk corridor ▪ Extensive network along several trunk corridors ▪ Coverage in areas of high social vulnerability ▪ Coverage in all areas	Lead agency planners, government officials, local authority representatives, transport authorities, traffic police department, international BRT experts, transport demand modelling consultants, local transport operators, general public, NGOs, CBOs, housing and business companies,	Transport OD demand modelling -GIS maps , social data, -Cost benefit analysis(MCDA)
Network design	***Site selection for*** ***Transfer points*** ▪ Adjacent location of depot and terminals ▪ Single or multiple station bays ▪ Station site spacing on demand or after fixed distance ***Utility lanes*** ▪ Total or partial relocation of utility lines	Lead agency planners, government officials, local authority representatives, transport authorities ,traffic police department, international BRT experts, transport demand modelling consultants, local transport operators, general public, utility companies, economists, local business	Transport OD demand modelling -GIS maps , social data, -Cost benefit analysis(MCDA)
System integration	***Site selection for*** ▪ Park and ride facilities or TOD activities	Lead agency planners, government officials, local authority representatives, transport authorities ,traffic police department, international BRT experts, transport demand modelling consultants, local transport operators, general public, utility companies, economists, local business	

4. BOGOTA AND THE TRANSMILENIO SYSTEM

This chapter describes the practical infrastructure planning process for the TransMilenio BRT. Being a model case, the review looks at the city of Bogota before TransMilenio and how the infrastructure planning process for the BRT was done. This allows for the real case comparison over what makes TransMilenio desirable to cities that are developing similar systems and what is it that planners are really doing in the BRT planning process.

4.1. Bogota's Traditional Public Transport System

The city of Bogota, is an important administrative and political city in the developing country of Colombia, South America. It covers an area of 1732 km^2 and is characterised by a CBD-focused urban form. The city's peripherals are characterised by high population density with a majority of the population being low income earners (Hidalgo & Graftieaux, 2010). Before TransMilenio, Bogota's public transportation systems had an oversupply of transit buses. This resulted from the transportation authority, Secretariat of Traffic and Transport, (STT) assigning operation permits for transport routes while being limited in resources and capacity to supervise and ensure regulations were enforced (Ardila-Gomez, 2004; Cain, Darido, Baltes, Rodriguez, & Barrios, 2006).

Bogota's public transport structure had 64 bus companies that belonged to trade associations headed by CEOs who could influence legislators. The bus companies however were not responsible for the actual provision of services. This was left to individual bus owners. Bus owners made the decisions on when and where to operate which always fell to routes that had high passenger volume (Ardila-Gomez, 2004). This left the public transport user vulnerable to the impulses of the bus owners' decision to ply certain routes at whatever cost they saw fit at the time (Figure 19). The general incapacity of STT to control the oversupply of fleet vehicles led to low quality public transport services that was characterised by high levels of congestions, excessive travel times, high pollution and traffic related accidents for the bus user (Cain et al., 2006; Hidalgo, 2002; Hidalgo & Graftieaux, 2010).

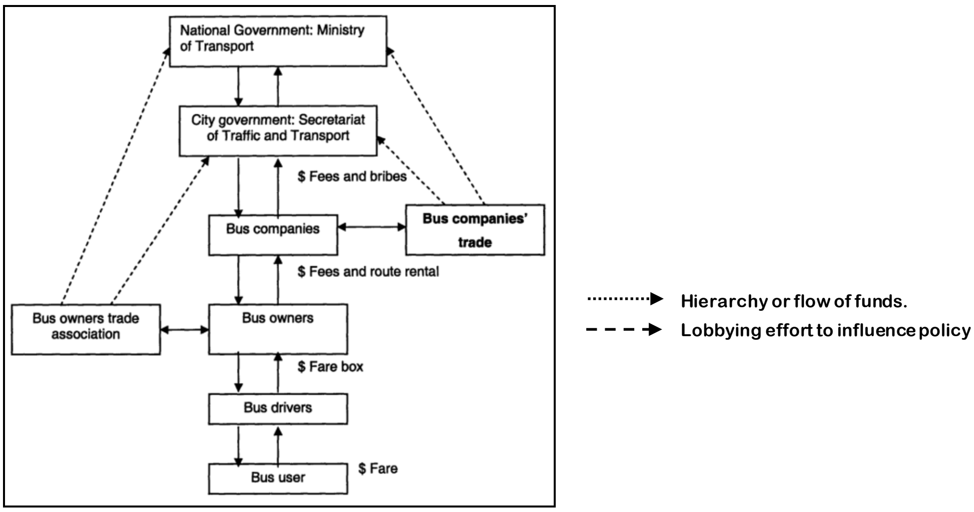


Figure 19 Organizational Structure of traditional public transit system
Source: Ardila-Gomez, (2004)

As an approach to resolving the transportation problems, several attempts were made to build heavy rail metro systems but the projects were constantly opposed by the existing public bus transport providers. In addition, the administration always failed to secure enough capital to establish the systems (Cain et al., 2006). The need for cost effective alternatives that made use of available resources Bogota had, led to the identification of an all bus network transit system for public transport, as was being experienced in Curitiba at the time (Ardila, 2002).

4.2. Planning the TransMilenio

Bogota's BRT project was part of the then Mayor Penalosa's political agenda to set up a public transport system with a vision of restructuring the city's mobility for a better city scape. When he got elected in 1997, the plan was approved in 1998 (Cain et al., 2006). A major strategy for the mayor was to recover pedestrian walkways, re-construct bikeway networks, and develop the BRT system for improved public space on the existing segregated busways facilities that were along the major corridors of Caracas Avenue, Calle 80 and Autopista Norte which the traditional bus operators had control over (Hidalgo & Graftieaux, 2010) (Cain et al., 2006; Hidalgo, 2002; Hidalgo & Graftieaux, 2010).

Recognizing bus operators as critical project stakeholders from their role in the decline of rail projects, the mayor assembled a team of experts who were to identify the strategies that would get the bus operators to provide services within the BRT system. In addition, the team was to report the project activities directly to the mayor. This process made use of discussion meetings and union assemblies to gather information about the public bus service providers, their concerns and conditions for which they could participate in the BRT project (ITDP, 2007a). The project leader was a business man with broad experience in finance and had the responsibility to coordinate other project stakeholders who would actualize the project. These included international firms like Steer Davies Gleave and McKinsey&Company who had experience in BRT implementation in other Latin cities, along with the local consultants and engineers to participate in the project preparation process (Ardila, 2002; Hidalgo & Graftieaux, 2010).

The mayor's directive to the planners was not just to adopt the strategy of Curitiba BRT, but adapt the concept of BRT into the local setting for it to serve the needs of the city (Ardila-Gomez, 2004; Hidalgo & Graftieaux, 2010). Institutionally the assembled team by the mayor formed part of the lead agency TransMilenio SA and was tasked with the planning, construction and managing of daily BRT project activities. As lead planners, they were under political protection and directives from the mayor to make use of both local and international experts to ensure the actualization of the BRT project (Cain et al., 2006).

4.2.1. TransMilenio stakeholders

The lead planners had to partner with the City Council in the project under the TransMilenio SA banner (Hidalgo, 2002).

To manage stakeholders the project leader established a small interdisciplinary group whose mandate was to coordinate activities with consultants and relevant city agencies from the planning, transport environment and utilities sector. These public agencies included, Secretary for Transportation and Traffic (STT), the Department of Planning, the Secretary of Finance, Metrovivienda, District Institute of Culture and Tourism (IDCT), Education and Road Safety of the Secretary of Transit and Transportation were classified as having most experience and were included in matters of design, planning and investing in the infrastructure. The local public works agency, Institute of Urban Development (IDU) supervised infrastructure building and their maintenance by local contractors. Collaboration was with local and international consultants, who advised on matters of feasibility and the main construction tasks (Hidalgo & Graftieaux, 2010; UNDP, 2011)

4.2.2. Demand Analysis for TransMilenio corridor selection

During phase one, basic alternative analysis was used which considered the ease of implementation and growth opportunities for a BRT system on the existing corridors. This led to the identification of seven busway corridors Mayor Penalosa wanted to have constructed within his three-year term in office. However, planners had to be realistic and manage the mayor's expectation while still securing support for the project. Negotiations led to the mayor agreeing to have three corridors implemented during his term and the other four during the next mayor's term. Hence the Mayor Penalosa had to facilitate the BRT corridors inclusion into Bogota's Development plan by the City Council to have the corridors implemented in phases (Figure 20). The phases were to follow no particular order so as to make the implementation flexible and fit to conditions of resources being available (Ardila-Gomez, 2004).

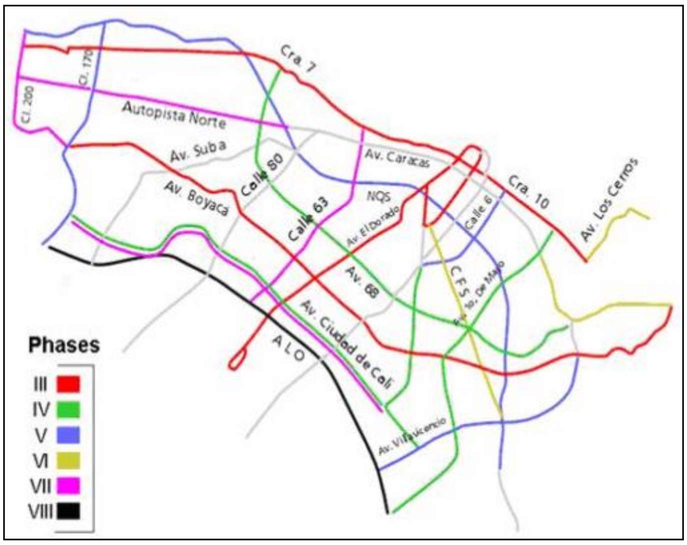


Figure 20 TransMilenio Masterplan
Source: Cain et al. (2006)

The corridor selection process for phase one, Caracas Avenue, Auto Norte and 80th Street, was a direct decision from the mayor (Figure 21). These routes were well known to the general public since they connected the CBD with the residential areas of the city. The routes also did not require additional land for the BRT to fit since busway was already operating on the corridors of Caracas Avenue which Autopista Norte and 80th street (Hidalgo & Graftieaux, 2010).

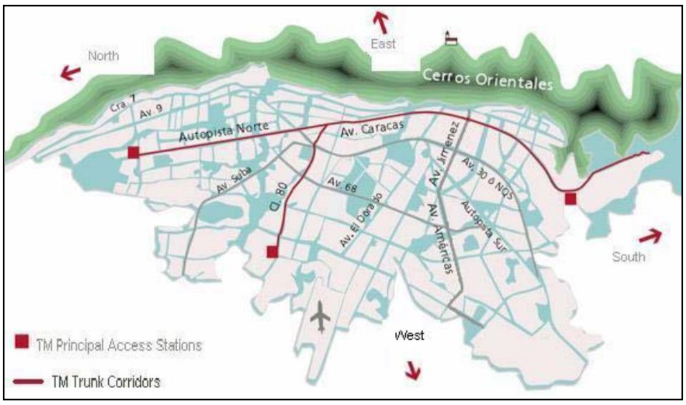


Figure 21 Phase one corridors of Caracas Avenue, Auto Norte and 80th street
Source: (Echeverry, Ibáñez, Moya, & Hillón, 2005)

Decision problems with phase one corridor selection resulted when some planners wanted TransMilenio to be implemented as a pilot to test the concept on the less busy 7th Avenue where displacing existing operators would be relatively easier. The mayor however insisted on Caracas Avenue since he wanted a fully functional project that achieved the objectives set. During the deliberation process between the mayor and local planners, international experts were consulted to provide advice on the matter of the initial road selection and they agreed with the Mayor Penalosa (Ardila-Gomez, 2004).

Caracas Avenue corridor would have elicited strong conflict with traditional operators which planners wanted to avoid. Mayor Penalosa saw Caracas Avenue as an opportunity to anchor the project in actual practise. Since restructuring the traditional transport system and perceptions was the most challenging part of the project, initiating the project in a dense transit zone was optimal to illustrate the true benefits of the BRT system to the society. By addressing it first, Mayor Penalosa was for the opinion it would set the pace for subsequent administrations to continue with the project (Ardila-Gomez, 2004). In addition, diverse income level communities were located along Avenue Caracas which for the Mayor meant the BRT corridor would serve the people of Bogota and not any particular group.

The decision making process for the selection of Phase two corridors Norte-Quito-Sur (NQS) Avenue, Suba Avenue and 13th Americas Avenue utilized the main criterion of connecting to high density areas of the city to increase the system's capacity(Hidalgo & Graftieaux, 2010). Norte-Quito-Sur (NQS) connected the dense southern areas and had the potential of extending the system to the neighbouring municipality of Soacha. Suba Avenue connected the middle and low income population located in the wetland areas. 13th Americas Avenue, was selected because the BRT terminal and depot site was along it. Having been earlier set aside for the metro depot, the similarity in land use made it easier to develop the transfer points. (Hidalgo & Graftieaux, 2010).

Phase three corridors selection utilized a detailed transport demand models together with matters of cost and impacts for the low income population. This led to the selection of Boyacá Avenue, Carreras 10 and 7 and Carrera 26-Av Eldorado (Figure 20). Boyacá Avenue characterised by an extensive north to south corridor of enough width space could accommodate two buses lanes in each direction, and another two for general traffic. The Carrera 7, however, with expensive and historical real estate property along the route limited the space available and challenged cost compensation in property acquisition. An alternative of building a tunnel was presented but would increases the cost. These created a decision problems challenging the corridor's planning efforts. Carrera 26-Av Eldorado selection was in relation to it connecting Bogota's airport to the CBD (Cain et al., 2006; Hidalgo & Graftieaux, 2010).

Steer Davies Gleave consultants tasked with the design using transport studies results from origin destination surveys, passenger counts at stops, boarding and alighting surveys included a stated preference survey to obtain more user centred information in relation to importance of walking towards a public transport facility and waiting for public transport (Lillo, Wensell, & Willumsen, 2003).

4.2.3. Designing BRT infrastructure

Once corridors were selected, the associated infrastructure had to be designed to ensure high efficiency. Spatially located infrastructure was to comprise of reconstructed exclusive busways, feeder routes, large and enclosed median stations with overtaking lanes per direction, terminals, depots, non-motorized facilities and pedestrian walkways(Hidalgo & Graftieaux, 2010). Summary of the infrastructure provided for the first two phases is illustrated in figure 22.

Where possible terminal stations were located at the end of each BRT trunk corridor and served as the main stations for entering the trunk and feeder routes. Intermediate stations were located approximately every 500 meters with mostly two bay stations within the median of the trunk (Cain et al., 2006).

	Phase I	Phase II		
		Americas	NQS*	Suba*
Length (dedicated busway)	41 km (25.6 miles)	13 km (8.1 miles)	18 km (11.2 miles)	10 km (6.2 miles)
Busway lanes per direction	1 / 2	2	1	1
Feeder network coverage	7 zones (309 km / 192 miles)	7 zones (509 km / 316 miles)		
Terminal stations	4	1	1	1
Intermediate stations	4	1	1	0
Standard stations	53	16	21	13
Pedestrian overpasses	30	10	25	4
Buses	470 articulated (trunk) 235 conventional (feeder)	+335 articulated (trunk) +200 conventional (feeder)		
Expected date of commissioning	Different sections opened between 2000 and 2002	Opened 2003/2004	North: 2005 South: 2006	Expected 2006
Cost ($US)**	$240M	$117M	$286M	$142M

Figure 22 TransMilenio infrastructure for phase 1 and 2

Source: Cain et al. (2006)

With focus on project stakeholders mostly centred on bus operators and their companies, public participation for TransMilenio has been described as scarce. The project discussions and deliberations were limited within the interdisciplinary group created, the lead project leader, the mayor and the city council. Large efforts however were invested in public outreach programs to educate and inform the public transport user on BRT system (Hidalgo & Graftieaux, 2010). Instances where stakeholders participated, interaction with the community stakeholders was in relation to planning the station aesthetics designs.

The process of planning with stakeholders often lacks meaningful collaboration. This resultantly solidity's the lack of trust among stakeholders that their concerns and suggestions would be incorporated into the planning process. This was illustrated by a handicapped group that was consulted but later took TransMilenio SA to court when the group realized that their considerations were mainly limited to the trunk service lines and less in feeder related infrastructures. The court ordered TransMilenio to have design accessibility measures in feeder zones as well (Hidalgo & Graftieaux, 2010).

In some instances, planners went ahead with design plans despite community opposition which often occurred when it proved difficult to agree on alternatives. This was especially challenging for locating of the bus depot stations. The 80th avenue street depot, as most depots in Bogota (Figure 23) was a source of conflict due to the amount of land needed (Ardila-Gomez, 2004). Optimal design of depots by having them in close proximity to terminal areas and at the end of trunk corridors as earlier described (see 3.1.2) is often a source of conflict. This is especially a challenge in densely build cities where vacant land is relatively difficult to acquire for such big project infrastructures. But a SDSS tools structure developed with the right information in line with the MC-SDSS described in Figure 8, the deliberation process might avoid conflicts after implementation. This process of property acquisition is usually costly and to get initial land owners to agree to offers presented is usually challenging and time consuming (Ardila-Gomez, 2004).

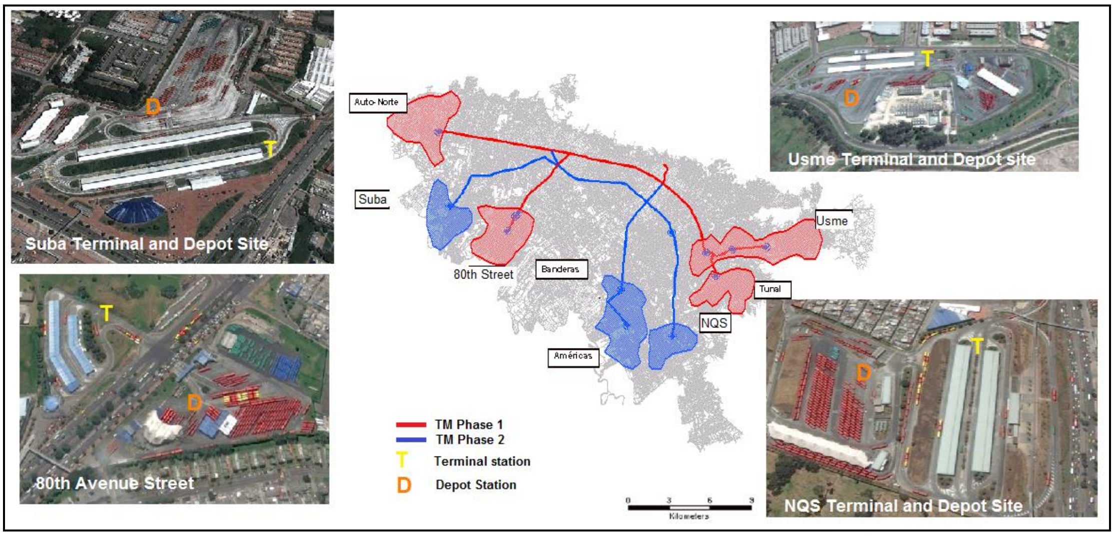


Figure 23 TransMilenio corridors, feeder zones and end point depots for Phase I (2000-2002) and II (2003-2005)
Source: Adapted from Hidalgo (2005), Google Earth imagery, 2016

4.2.4. Integrating TransMilenio

TransMilenio plans provided extensive bicycle lanes and storage facilities in and around the BRT stations as an approach to promote a ride and park culture. Future goals associated with the infrastructure was a behavioural change. It was anticipated by planners that by having cycle lanes the bicycle would be used as a daily mode of transport. This in turn that would help reduce the costs from running feeder bus services outside BRT trunk corridors (Moller, 2010). Cain et al. (2006) study showed that the popular modes of accessing TransMilenio stations were walking, followed by the use of feeder and traditional bus services. Despite the efforts, use of bicycles to access BRT stations recorded the lowest with 2 % when compared to the other modes (Figure 24).

Moller (2010), insight on cycling in Bogota that could explain such low figures is the failure by decision makers to factor in the culture of the people in relation to cycling. The real need for cycling was for it to cover short in between neighbourhood distances and not long across the city scape distances; a practise the citizens have been reluctant to adopt. A contributing factor being the continued risk cyclists face from motorized traffic. This dissuades the use of the bicycle as a daily mobility mode (Moller, 2010).

Mode	Percent
Feeder System	26
Traditional Bus System	20
Regional Buses	5
Walking	47
Bicycle	2

Figure 24 Mode of access to TransMilenio Stations
Source: (Cain et al., 2006)

4.3. Reflection on TransMilenio planning process

Review of Bogota's TransMilenio planning process to provide a base for comparison between real planning cases, illustrated Bogota indeed had an influential public bus transportation sector that influenced the success or failure of other transport systems. The mayor recognized this and made initial efforts to focus on getting the bus companies and operators to favour the BRT project over the existing system. By insisting that the initial implementation phase be on the major Caracas Avenue amid concerns from local planners over the bus operators' reactions, the project benefits that the users experienced were strong enough to support the mayor to continue with the project. It is assumed this also encouraged subsequent administrations to continue with the same. In addition, it is assumed that the shift in passengers, motivated other bus operators to shift to the new BRT system.

However, it can be said that the BRT project had a relatively capable setting for BRT to be implemented. The BRT project was part of the Mayors political agenda and the initial corridors on which the BRT corridors were designed had existing bus way lanes. The mayor as well handpicked the planners and corridors directly or indirectly with the use of a "capable" group who made most of the decision in regards to the project. This makes it open to criticism on how open and transparent the process was to utilizing information provided by stakeholders. Not all bus transport companies joined the concession companies and matters of relocation planning of the routes are not elaborated as much. Studies that have looked into the shift from direct to feeder lanes in TransMilenio illustrate a lack of dialogue that has forced the bus companies to cluster in areas BRT is not planned for. This has consequently shifted and intensified congestion to other lanes outside TransMilenio routes (Ferro & Behrens, 2015). The relatively blind replication of TransMilenio inherently means the adoption also of the problems it has created. Therefore, sound judgment by planners and decision makers in matters of project or program policy transfers and adoption should be applied. TransMilenio insists on engaging bus companies and owners. But in the complex multi-actor setting of the public transport, other stakeholders should be considered in a relatively well balanced process of engagement.

The bus transport companies were key project stakeholder who could have impeded the project. The strategy of presenting the project as a business plan to the bus operators and companies proved to benefit the project. However from the perspective of how this study defined stakeholder participation in decision making and planning, (see 3.1.1.1) the approach of using a business man to present and sell the idea of BRT as a business venture could be viewed as manipulation of the stakeholders.

Some of the decision problems that TransMilenio experienced is summarized in table 4.

Table 4 TransMilenio spatial decision problems

Planning task	**Spatial Decision problem**	**Stakeholders**	**Decision making tools and strategies**
Corridor selection	***Selection of type of BRT solution-*** ▪ Implementation of pilot corridor in less congested routes ▪ Design of full BRT system in bus congested corridors	TransMilenio SA lead agency planners, Mayor's office, City council office, Institute of Urban development, Steer Davis Gleave transport demand modelling consultants, international BRT experts, local transport operators, legislators, finance secretary	-Alternative analysis -Transport OD demand modelling results Feasibility study
Network coverage extent	***BRT characteristic*** ▪ Standalone pilot corridor ▪ Full coverage of city in areas of high social vulnerability ▪ Full coverage in all parts of the city	TransMilenio SA lead agency planners, Mayor's office, City council office, Institute of Urban development, Steer Davis Gleave transport demand modelling consultants, international BRT experts, local transport operators, legislators, finance secretary	

Network design	***Corridor space*** ▪ Provide BRT tunnel and increased project cost Acquire property and increase in project cost ***Selection of sites*** ▪ Adjacent location of depot and terminals at end of trunk corridors ▪ Location of depots and terminals on available space away from corridor	TransMilenio SA lead agency planners, Mayor's office, City council office, Institute of Urban development, legislators, finance secretary, general public	
System integration	***Bicycle lanes*** ▪ Provision of cycle lanes for short neighbourhood distances ▪ Provision of cycle lanes for entire BRT lanes	TransMilenio SA lead agency planners, Mayor's office, City council office, Institute of Urban development, general public, community based organisations, , finance secretary,	

5. RESEARCH METHODOLOGY

This chapter describes the methodology the study applied to investigate how the Dar es Salaam BRT known as DART was done. It provides an overview of the research design followed by the pre and post field work activities.

5.1. Research Study Design

Overview of the research methodology is illustrated in figure 25. To investigate how the planning process for BRT infrastructure is done, the study made use of both primary and secondary data. First step was identifying literature of BRT planning process with the review guided by the themes of stakeholder participation, decision problems and SDSS. This helped build the concepts of the study and prepare for the field work. Field work preparations entailed going through documents for DART to identify the project stakeholders, making initial contacts, booking appointments and preparing the research tools for the interviews. This included the interview guides and closed ended questionnaires. The data was then collected, analysed and the information obtained integrated with earlier reviewed literature. This guided the final part of the study which identified the common spatial decision problem that was to guide the structure of the SDSS development for BRT planning tasks and activities using the case of DART.

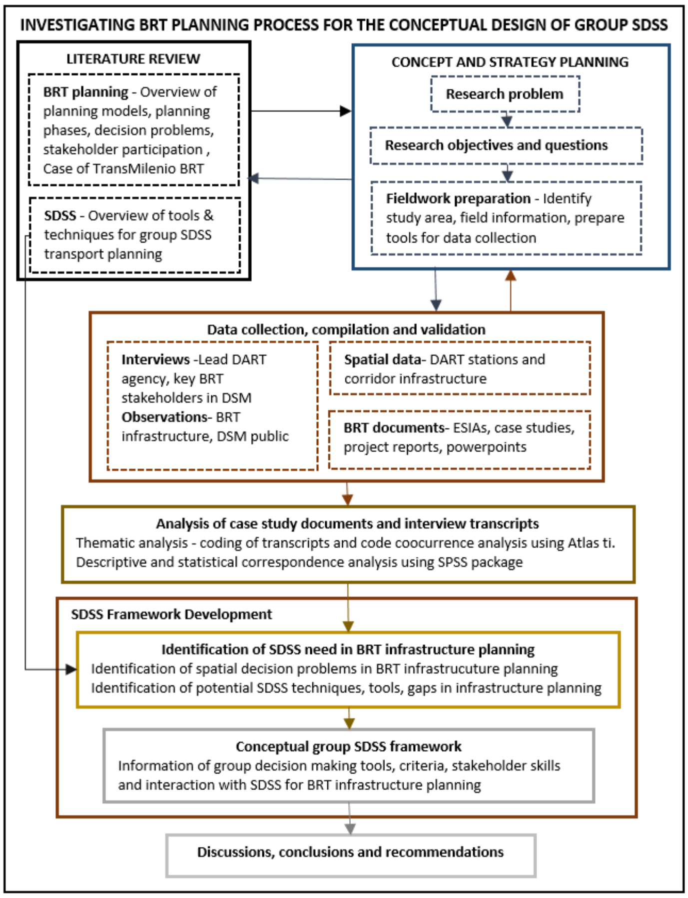


Figure 25 Research design

5.2. Data Collection

5.2.1. Literature review

Relevant literature reviewed was sourced from journal articles, organisational reports, PhD theses, e-books, online news articles and blogs, that had information focusing on the BRT planning process, stakeholders and the applicability and development of SDSS tools in road transport planning. The references listed in identified articles were used to identify other relevant literature. This process was made iterative to try and establish information saturation that would improve the validity of the information used in the study.

For the investigation into the BRT planning process, the ITDP planning guide was reviewed to understand the process and highlight decision problems that are associated with BRT planning. TransMilenio as a model case was reviewed to provide a practical case for which to compare the planning process of DART in addition to the comparison with what ITDP states. Papers by Adrila Gomez in information relating to stakeholder roles in BRT planning and Dario Hidalgo in infrastructure studies, were often referenced. Hence documents published by these two authors either individually or in collaboration with other authors served as a reference base to snowball to other relevant articles. These activities addressed the first objective of understanding the BRT planning process for infrastructure planning.

For the field work, information was mainly sourced from online reports from the DART agency, ESIA report and World Bank documents to identify the key organisations that had a stake in the BRT project. Institutions that recurred from the different documents formed the sample frame of the study for the interview sessions carried out. To make stakeholder classification easier, definitions as provided by to Civitas (2011) was used. Hence for the study, primary project stakeholders are those affected either positively or negatively by a project. In transport they can include citizens, social groups or businesses. Key actors are stakeholders with power or expertise needed to execute a major part of the project activity. They include those with political responsibilities like mayors, councillors, those with financial resources or even those who have good rapport with local people. Intermediaries are stakeholder who have an influence over the decisions made. They include police, public transport providers who implement the policies, NGOs and the media.

5.2.2. Interviews and questionnaires

The initial task for the interviews involved a pilot of the interview schedule. This was done on three fellow students who took up roles as respondents. At the time, the guide was assessed in terms of the interview's duration and how clear and extensive the questions were to cover the study objectives. But even though pre-tested, much of the interviews were dependent on the interviewee responses. This led to the restructuring of the guide in the field to improve on its clarity, while still capable of answering the research questions. Before commencing the interviews, respondents were informed about the study details and given assurance about the study's ethical principles, of anonymity and confidentiality and right to decline participation (see annex 2).

The semi structured interviews were conducted predominantly on a face to face setting using a question guide (see annex 3, 4) and closed ended questionnaire (see annex 5). The later instrument was to gather stakeholder opinions on what planning activities would benefit from a SDSS tool applied in the decision making process. These were the main tools and methods for the study's data collection undertaken from

September 26th to October 13th 2016. Appointments were made at the convenience of the respondents, which challenged the study with impromptu and constant rescheduling and cancellation of interviews.

Allocated time per interview was structured for minimum 40 minutes to try and capture as much information on the DART project. Key informants included managers, road engineers, DART staff and BRT specialists earlier identified from literature. For each key stakeholder organization, the sample size was set for at least two people who were involved in any deliberations regarding DART's planning process and where spatial related problems could occur. For the lead DART agency, the initial sample was set at five respondents. This was to obtain information from two officials handling different spatial related tasks in the agency's operations and infrastructure management section, two from transport planning and one from PR and communications. DART being the lead agency of the project justified more respondents of different capacity in the DART project. Since the interviews were mostly done during office hours, office duty interruptions were common.

The semi structured interview approach allowed the interview to follow up on ideas and get detailed and elaborate responses for information that was of importance to participants but may not have previously been thought of by the research (Pacho, 2015). Outputs from the interviews included audio recordings as well as documents the respondents provided. In some incidences email correspondence was used due to conflicting schedules. Final interview composition included 17 respondents. This comprised of three respondents from the lead agency DART representing the departments of operation, social studies and transport development. The other respondents included the road agency TANROADS, national environmental agency NEMC, local consultant, Interconsult, utility companies for water DAWASCO and electricity TANESCO, former DSM city council man, municipality officer for Kinondoni, representative from the paratransit company of UDART, traffic police officer and stakeholders from the transport education center NIT (see annex 6)

5.2.3. Observations of DART Phase 1

Field observations were made to supplement the documentation and interviews. Photographs and notes were the primary data collection tools. The observation protocol was to observe and make notes of DART phase 1 trunk corridor, stations, corridors, and feeder routes. Hence walking sessions along the main trunk and future DART corridors by the researcher was done and note taking subjectively describing the infrastructure. The aim for this activity was to link the outcomes observed to the decision making process reviewed for better understanding of the role of decision making process to project outcomes.

5.3. Field Data Analysis

General procedure for the qualitative data analysis was categorisation, development of concepts/theme and interpretation of the data collected (Figure 26). The first stage involved the sorting out of the data collection outputs, audio recordings, questionnaires, guide notes, report documents, email exchanges and spatial data to identify documents for thematic analysis and those for further literature build up.

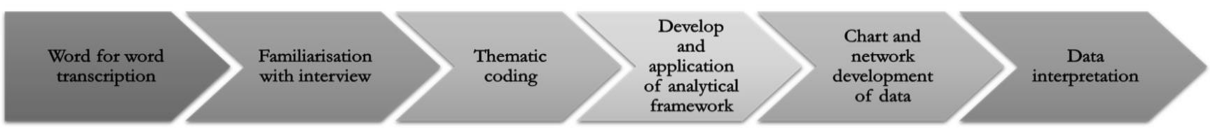


Figure 26 Methodology for interview data management and analysis
Source: Adapted from Gale et al. (2013)

ATLAS.ti software was the main thematic analysis tool and the process of analysis followed the steps of open, axial and finally selective coding as described by (Johannessen & Hornbæk, 2014). In line with the research objectives, content analysis themes included collaboration strategies, stakeholders, stakeholder roles, BRT spatial decision problems and the need for SDSS. General quotes were identified from each transcript document that reflected information about a concept. These were further refined to structure codes that built up into the themes. As an iterative process this allowed the data collected to provide information that addressed the second research objective. To effectively manage the growing list of codes, information network views were utilized help understand the relationships between themes for better interpretation of the data (Friese, 2014). In addition, the code co-occurrence tool was applied to understand the meanings of the networks as well as examine the strength of the relationship between the codes using a coefficient function. The co-efficient allows the study to perform a quantitative analysis on qualitative data to illustrate the intensity of concepts being associated with each other from a scale of 0-1; stronger relationships between codes having values closer to one (Friese, 2014; Lewis, 2016). This technique helped in understandings how the stakeholders perceived each other in respect to their roles

Responses from the closed ended questionnaires was analysed using SPSS statistical package. Correspondence analysis was used to enable the visual assessment of relationships (Prouty et al., 2016) of the stakeholders' opinions of SDSS for a planning task. This also offered statistical basis for developing a tool that most experts agreed on as having a higher need for a SDSS tool.

5.4. Information development for conceptual SDSS

For the conceptual design of a BRT related SDSS tool, examining of the planning process tasks was a key step to understanding how project stakeholders could be effectively supported during a decision making process. The output from the field and literature review of BRT planning processes was used to identify decision problems, data needs, stakeholders and their skills, existing tools, techniques and strategies that facilitate decision making. This classification helped identify the elements that could constitute the BRT's SDSS structure from a focused literature overview of group SDSS concepts and techniques (see section 2.2). This information was utilized to first establish the potential structure of the BRT-SDSS before discussing matters of design and application (Kok, Kofalk, Berlekamp, Hahn, & Wind, 2009).

Literature on SDSS design and application made use of decision making hand books, and articles in the field of transport planning, urban planning and ecology. Despite the differences in fields, the study adapted principles that focused on group SDSS structures facilitating spatial planning of resources. The design frameworks adapted the IDSSE-M methodology which follows a prototype based approach comprising of five phases; project initiation, system design, system building and evaluation and user acceptance (Jain & Lim, 2010). The methodology was well suited for the study since the study objectives aligned with the methodology activities. In project initiation a decision making situation is recognized and a DSS justified. The study identified decision problems, and estimated expected benefits from the SDSS and users from addressing objective one of the study. System design is done from the literature review and the field data, identify what structures could be incorporated in a BRT related SDSS. The third phase of building and evaluation, is the testing. This study illustrates a prototype application of the conceptual SDSS framework using the case of DART project. User acceptance for this study was limited due to the prototype not being applied in the actual decision making process with stakeholders. A critical view, however, on the tools applicability was presented to serve as a closure to the tools application.

6. CASE STUDY: CITY OF DAR ES SALAAM

This chapter introduces the case study area of Dar es Salaam (DSM) and the state of its public transportation system before describing the planning process of its BRT project DART.

6.1. Introduction to Dar es Salaam, Tanzania

Dar es Salaam (DSM) is a fast growing port city located in Tanzania, East Africa and is administratively divided into three municipalities, Kinondoni, Ilala and Temeke (Figure 27). These municipalities are further subdivided into a total of 73 wards and 383 sub-wards that cover a total area of approximately 1800km2 (DART, 2009).

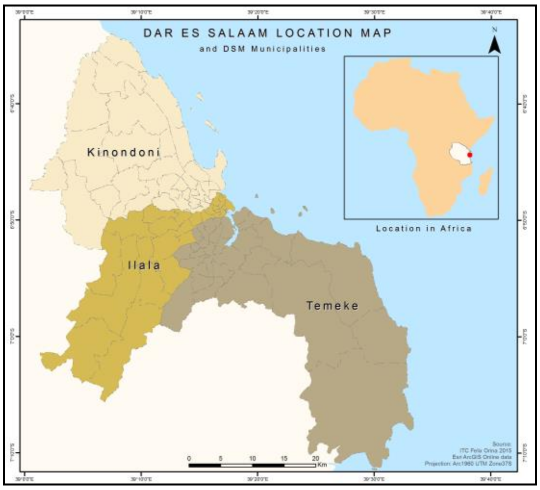


Figure 27 DSM location and administration map
Source: Researcher, 2016

Some of the challenges that persist and hinder development in DSM include poor quality infrastructure for its transport networks, high rates of unemployment and immigration, low technology use in productive sectors and low quality education (DART, 2007; GoT, 2016). A major concern for planners is that without development policies effectively in place, these challenges will only get worse with the increase in urban sprawl and illegal settlements in the city (JICA, 2008).

Urban growth of DSM has generally been along the major roads that connect the city center to the outskirt areas (Figure 28). As reported by Mzee and Demzee (2012) between 1978 to mid-1990's the distance between the city center to the edges has increased from 15 km to 30km. The areas between the radial corridors tend to be prime land for unplanned neighbourhood development with little road infrastructure and loosely defined paths (DART, 2007b). Estimations have about 70% of DSM's population living in unplanned settlement areas with housing densities of 480 people or 35 units per hectare above the recommended levels of 225 people or 22 houses per hectare (DART, 2007b). The municipality areas of Kinondoni and Ilala are characterised by middle, upper-middle and high social class residents while Temeke has lower economic groups of medium-lower to low income population (DART, 2007).

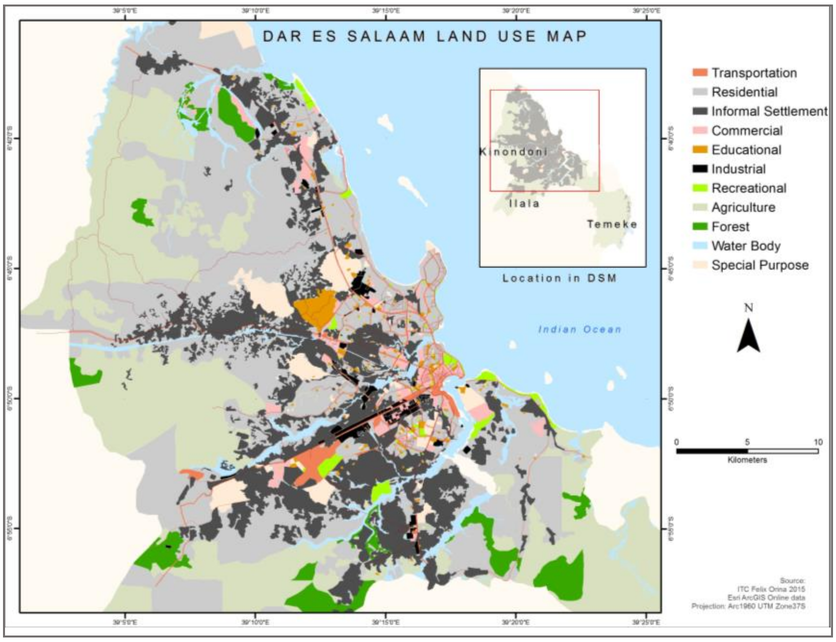


Figure 28 DSM land-use and urban fabric map

Source: Researcher, 2016

6.2. Dar es Salaam's Public Transportation System

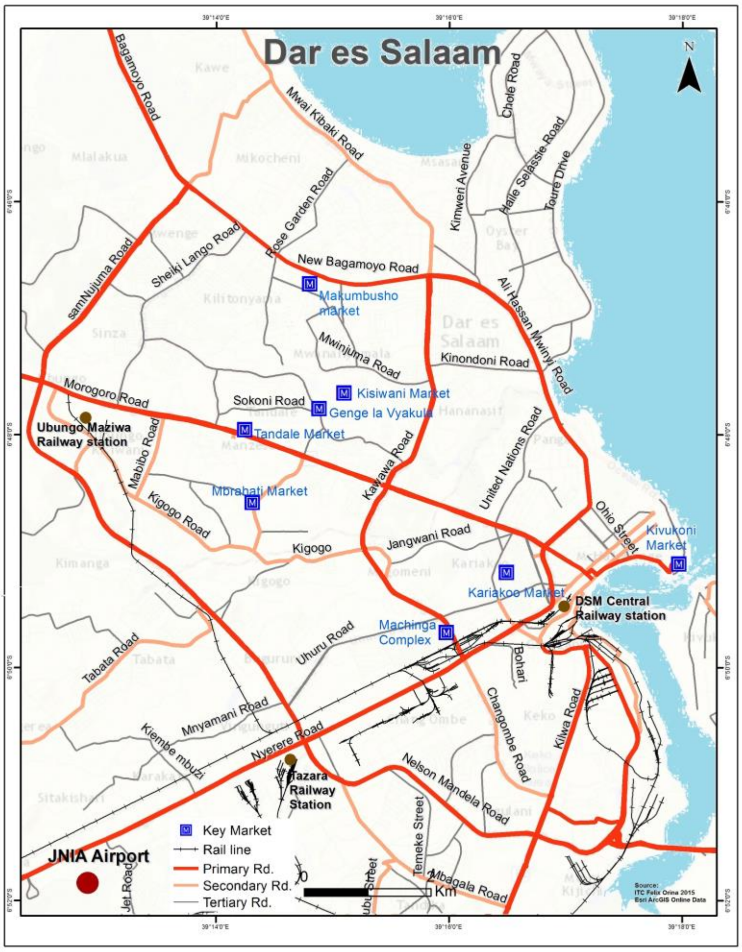


Figure 29 Dar es Salaam transport infrastructure

Source: Researcher, 2016

The DSM transport network constitutes of relatively fragmented networks of air, railways, ports (ferry) and road transport. The DSM's commuter railway services, that were introduced in 2012 function on two rail lines; TAZARA HQ to Mwakanga in the south and the other Ubungo Maziwa to DSM central railway station in the CBD (see Figure 29). Service operations are limited to the morning and evening peak travel hours (DART, 2014a). Consideration are in place to introduce far reaching commuter train services that will connect neighbouring cities, yet the limited coverage system is declining as a result of poor performance of the locomotives and a lack of regular and efficient maintenance (GoT, 2016). The main Julius Nyerere International Airport (JNIA) functions and services are weakened by inadequate and poor condition of facilities like constrained terminal buildings and poor carrier and airport services to meet traveller needs for both domestic and international flights. This has been attributed to management and financial issues (GoT, 2016). DSM as a sea port city has ferry services at Kivukoni. The ferry services are key to accessing the Kigamboni suburb area, but the system's capacity is limited. Hence plans to introduce more ferries are being considered (DART, 2014a). DSM transport systems are weak and some intervention methods can be described as having misplaced priorities in relation to improving the services offered.

As described by JICA (2008) DSM has national roads that fall under the TANROADS and the Ministry of Infrastructure Development Executing Authority. Local roads are under the municipalities and the DSM city council which is usually involved with cross cutting issues among the municipalities. The consequences of this administrative structure is that roads are not classified by functional roles hence there are no consistent designs for local roads; designs for intercity roads may not necessarily be functional for the urban conditions (JICA, 2008). In relation to the BRT planning models, this nature of the road planning structure would make the TRB model approach more viable. As discussed in section 2.1, the TRB model structure considers participation of the multiple administrative units in the planning process so as to develop and integrate transportation systems that links the system irrespective of the systems jurisdiction (see Figure 6). Such an approach does not allow any one agency to be responsible for the development of the transit elements provided in an area and requires collaboration of the administrative institutions.

The general road capacity in DSM is inadequate with scarce paved roads (Figure 30) that are usually worn out with limited sidewalks, unpaved or occupied by parked cars (DART, 2007b; Ka'bange, Mfinanga, & Hema, 2014). Lack of space in the CBD plays a critical role in the lack of adequate parking space needed to cater for the rapid motorization of the city. Other basic road infrastructures like lights are mostly non-functional and road signs lacking. Administratively, traffic enforcement is weak as inferred from the high cases of road related accidents. Statistics show that 40% of the country's traffic accidents occur in DSM city (DART, 2007b).

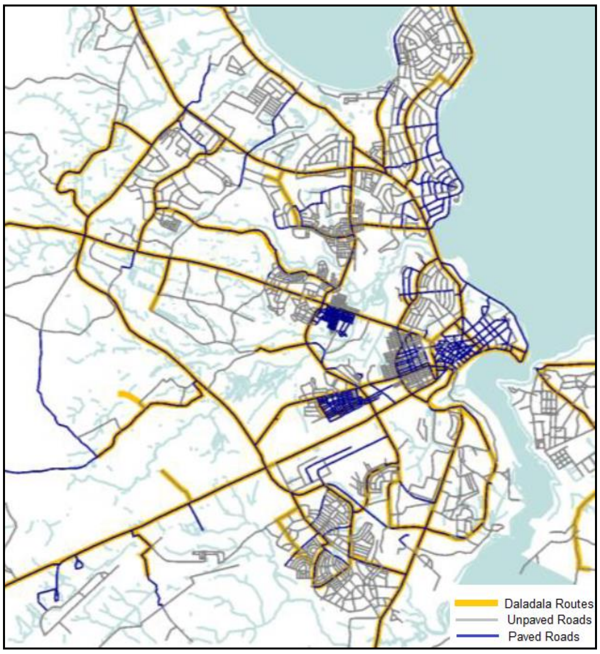


Figure 30 DSM minibus operation routes
Source: (DART, 2007b)

Of its approximately 1140 km of roads, only around 265 km is used for public transport that operate under mixed traffic with cars, motorbikes and carts (DART, 2007b). Trips to the inner city that are made by public transportation accounts for 43 %, non-motorized transportation at 45% with private cars at 6% (DART, 2009). The dominating paratransit vehicles are the daladala, paratransit minibuses. Others include the three motor wheeled, locally known as bajaji, and motorcycles, bodaboda, (see annex 9) that are used to cover short distances not covered by the minibuses (Ka'bange et al., 2014). An absolute number of these transport vehicles in DSM's network has been approximated to be 7000 daladala buses (Ka'bange et al., 2014) while motorization estimates are at around 180 000 cars on the roads (DART, 2014b). The primary networks and few paved lanes in between them constitute the network on which public transport minibuses operate and often generate frequent traffic congestion (Figure 30).

Worse case scenarios of DSM's public transport for users can be an average walk of 0.5 to 1 km (10-30 minutes) to the nearest route station where the average time spent waiting for a bus can range from 15-30 minutes. This is because the buses are unscheduled and susceptible to delays from mixed traffic congestions. During peak hours, travel times can range between 2-3 hours depending on the concentration of passengers and location of the user along the route (Ka'bange et al., 2014). Kombe et al., (2003) highlights incidences of bus drivers changing routes in between trips despite users paying for a full service. This results either from too much traffic congestion along the designated service line or notification of increased demand in another route. Similar case to Bogota from the bus owner controlled services in which route services could be changed at any time.

Rules and regulations have been set by Surface and Marine Transport Authority, SUMATRA, the institution responsible for public transport regulation to instil order and safety. The enforcement team, which is mainly the traffic police department have tried governing the public transport providers. However, efforts have been weak (DART, 2007b). Resultantly, DSM public transport system has been characterised by poor infrastructure, low quality public transport service and lack of safety for motorized and non-motorized transport users, including pedestrians (Figure 31)(DART, 2007b). These scenarios are relatively similar to the settings experienced in Bogota before TransMilenio that were discusses earlier (see section 4.1)

Figure 31 Challenges of space quality and traffic in DSM road network
Source: Researcher, 2016

With the disorderly state of DSM's public transport system that is characterised by paratransit systems and the relevant authorities seeking ways of controlling the unruly service providers, the ITDP model presented then would be a viable choice. To better understand how the BRT planning process was done the field case results section of this study is presented in the next chapter.

7. DART PLANNING PROCESS

7.1. Introduction of DSM BRT project.

With a deteriorating public transport system in DSM and UNEP looking to develop a pilot BRT project in Africa, the BRT lead agency ITDP drafted a BRT proposal in 2002 and approached a relevant local NGO, Association for the Advancement of Low Cost Mobility AALCM. The NGO then presented the concept to the Mayor who accepted and established the project as a development priority for the council, endorsing it a year later. With the mayor championing the project at ministerial levels, the conceptual design was completed in 2005, and the lead agency DART was formed under the then prime minister's office (DART, 2007b). The project's steering committee was established which consisted of directors and managers of active transport stakeholders. Funding was made available by World Bank, UNEP and USAID after which the construction of the DART project was inaugurated in 2010, and operations began in 2016 (DART, 2007b). Overall the planning process for DART took over a decade to conceptualize, plan and actualize the project's first phase of 20.9 km.

7.2. Project preparation

In the DART project, the lead agency set up a planning process that was led by demand studies (Figure32) and the main planning processes included design, implementation and operations (DART, 2009). The studies were to guide the setting up of the operations, infrastructure and a business plan and designs. This was reflective of the ITDP model's structure for a business oriented approach that forms bus companies from existing bus operators into the BRT project.

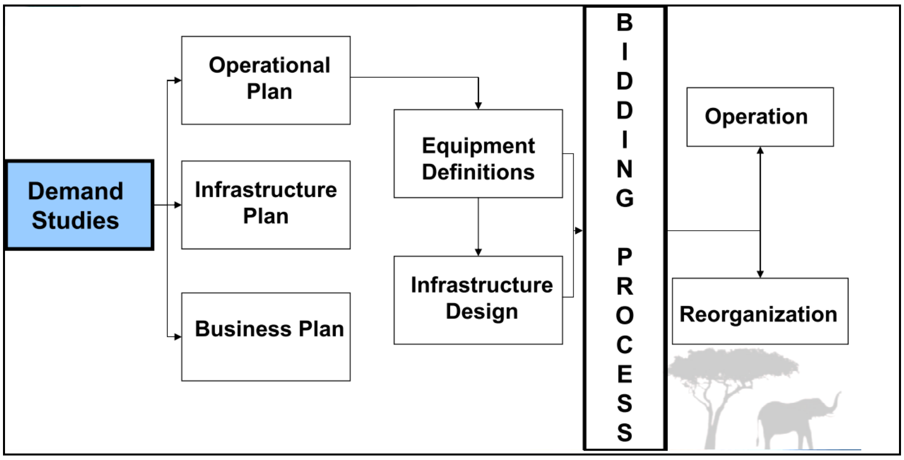


Figure 32 DART planning process
Source: (Mlambo, n.d.)

7.3. Stakeholders for DART Infrastructure planning

From the interviews, qualitative analysis enabled stakeholders to be identified and grouped (Figure 33). The category of key stakeholder/actors included those with power or expertise needed to execute a major part of the project activity. Primary stakeholder, were those affected either positively or negatively by a project. Intermediaries, comprised of stakeholders who had influence over the decisions (see section 5.2.1). Despite the categories, some stakeholders were categorised in more than one group depending on the activity since stakeholders offered different skills and were impacted differently in relation to the different tasks done in the planning process. How they interacted as well depended on the planning task (Figure 35)

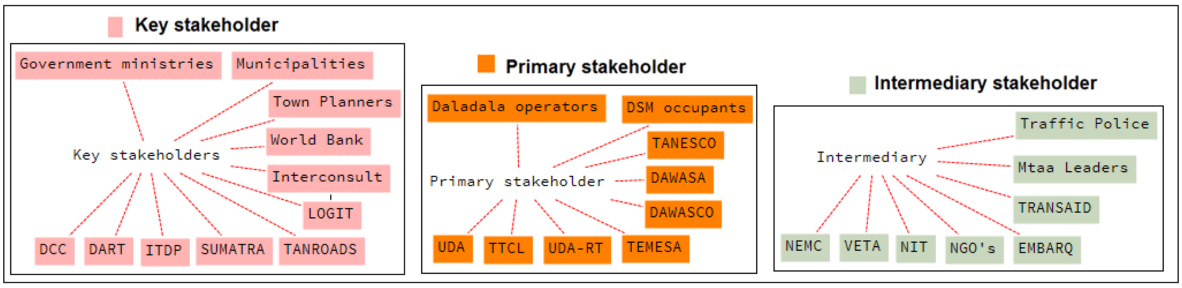


Figure 33 Project stakeholders in DART

Source: Researcher, 2016

To relatively quantify the degree of the stakeholders being in a particular stakeholder group based, code co-occurrence coefficient using ATLAS.ti was applied (see section 5.3). The results (Figure 34) highlighted government ministries as dominant key actors in the project with a code co-occurrence coefficient of 0.42. DART Agency ranked second with 0.38. In the DART project, the central government was fundamental in providing an enabling political setting, establishing legislature relating to setting the operational standards for the DART project in addition to project monitoring. The Presidential Delivery Bureau (PDB), as an independent department under the president's office had the mandate to follow up on implemented government projects (DART, 2014a). PDB was to ensure top leadership monitored the investments made in prioritised areas like transport. This office provided a channel for high-level intervention meetings and discussions for the lead agency planners at ministerial level. DART agency was to oversee the planning process of the project and report administrative implementation and management matters regarding the DART system back to the Ministerial Advisory Board (DART, 2014a).

	KEY ACTORS	PRIMARY STAKEHOLDERS	INTERMEDIARIES
DSM occupants	0	0.79	0
Government ministries	0.42	0.08	0
DART	0.38	0	0
Daladala operators	0	0.38	0
DAWASCO	0	0.38	0
Traffic Police	0.09	0.09	0.17
TANESCO	0	0.33	0
SUMATRA	0.15	0.05	0.11
Interconsult	0.27	0	0
LOGIT	0.27	0	0
Mtaa Leaders	0	0	0.27
TANROADS	0.25	0	0
Municipalities	0.07	0	0.18
DCC	0.13	0.06	0

	KEY ACTORS	PRIMARY STAKEHOLDERS	INTERMEDIARIES
DAWASA	0	0.2	0
World Bank	0.19	0	0
NGO's	0	0	0.1
UDA	0	0	0.1
EMBARQ	0	0	0.09
TRANSAID	0	0	0.09
TTCL	0	0.08	0
NIT	0	0	0.08
VETA	0	0	0.08
Town Planners	0.07	0	0
ITDP	0	0	0
TEMESA	0	0	0
UDA-RT	0	0	0

Figure 34 Code co-occurrence coefficient table of stakeholder's classification from respondents

Source: Researcher, 2016

Local design consultants known as Interconsult and international design consultants LOGIT were partners in the project. Hence the similar co-occurrence score of 0.27. The consultants were to conduct the environmental and social impact mitigation and management (ESIA) study in addition to drafting the project's detailed design and engineering development plans. While LOGIT provided external expertise in modelling using Emme/2 software and BRT related designs, Interconsult conducted the demand and travel behaviour studies for DSM. During this activity, SUMATRA, key stakeholder, provided route information. Interconsult identified survey collection points and together with the university of DSM faculties, traffic police daladala owners and the general public the origin-destination surveys and traffic counts, demand studies were done. Interconsult in addition organized the community outreach sessions for stakeholder analysis. The collaboration between the consultants was needed to develop the resettlement action plan (RAP) as part of the ESIA study. RAP helped identify the general social economic profile and estimates of the magnitude of displacement along the corridors (DART, 2007b).

Since the public was viewed as the most affected by the project with a co-occurrence coefficient score of 0.79, detailed questionnaires were administered to obtain information from the project affected people (PAPs) and statistical analysis incorporated to build the social economic settings of the population along the corridor. This information was important for the government land valuers, ministry of housing, ministry of finance, DART agency planners, local authorities, liaison community group leaders, home owners, religious centres, and PAPs to facilitate identification of relocation sites that were of similar value (Table 5). Invitation letters were sent to key community leaders informing them of upcoming project meeting they needed to attend for deliberations. Communication of project information to the public made use of disclosure sessions and town hall meetings. Acting as mediators during the meetings were the grievances committee members who were always present to document issues raised and follow up on agreed activities (DART, 2007b). It can be inferred that in the BRT decision making process, documenting of the information is a key activity that helps to review decisions and investigate the actors in accordance with what had been agreed upon. Having mediator roles is also import to help manage conflicts that may arise in the decision making process.

Local public transport service providers, daladala operators, were primary stakeholders who had either their service routes terminated or rerouted. Communication efforts for this group included workshops which was a major platform for sensitizing the daladala leaders (Figure 36A). Other stakeholders present were DART, Interconsult/LOGIT, the transport authority SUMATRA and the national roads authority, TANROADS. Collaboration was needed to establish complimentary initiatives which included the identification of potential BRT catchment areas and potential feeder roads by consultants. This followed the concerns provided by daladala operators that alternative routes would be on poor and unpaved roads (DART, 2014a). Since TANROADS had the technical capacity to implement the project routes which they did through the private contractors STRABAG and consultants SMEC (DART, 2014a) and SUMATRA assigned permits for daladala operations, they were key stakeholders in this session. For the planners the workshops allowed them to understand the stakeholders, identify factors of trade-offs, identify alternatives and assess how other stakeholders responded to the alternatives. For the technical plans between TANROADS and Interconsult/LOGIT decision-making strategies involved evaluation of designs using cost benefit analysis (Figure 36B). But despite the importance of this deliberation session, the feeder routes for phase one have not been well structured to the BRT operations with only a few stations built.

DSM City Council was grouped as a key stakeholders since they were more familiar with the concept of non-motorized transportation. The City Council had experience working with World Bank under a Sub-Saharan Transport Program (SSTP) and had implemented successful projects (DART, 2014a). Since they were familiar with both World Bank and DSM development protocols they were key for securing both project support and funds. Municipalities were considered to be intermediaries due to most of their activities targeting the facilitation of community liaison groups “Mtaa leaders” to coordinate with locals during public disclosure sessions. In addition the municipalities collaborated with the liaison groups to solicit community knowledge on available spaces and potential social issues of relocation. This local information was to be provided to planners and consultants for consideration in the identification of relocation sites.

Utility companies for Dar es Salaam Water Supply and Sanitation Company (DAWASCO), Tanzania electricity supply company (TANESCO), and Tanzania telephone communication limited (TTCL), were of importance to the project since they had to relocate their infrastructures from the right of way areas for BRT corridors. The typical characteristic of BRT infrastructure as described earlier in section 3.1.2 on designing BRT networks. This process was considered to have been more collaborative. It involved the utility companies, TANROADS, Interconsult/LOGIT sharing information either through digital or paper maps to identify the location, and nature of the infrastructure along the corridor. They also identified utility lines that could be placed under the pedestrian walk ways reducing the cost of relocation for the utility companies (Figure 37A). But due the lack of updated maps and spatial information, field visits were necessary to confirm the data provided which was time consuming to the project. Due to the unregulated development of DSM, some locations could not be accessible or proved to be costly in negotiating potential demolition for the identification of the infrastructure since they had residential or commercial building.

Local transport training centres that included the National Institute of Transportation (NIT), Vocational Educational and Training Authority (VETA) and university professors specialized in transportation planning, urban planning, environmental management were contacted to contribute their views towards adjustment of the DART project to better meet local needs. NIT was consulted to take part in stakeholder analysis meetings to identify the key players in DSM transport sector. In general, however, the role of research institutions was limited.

Technical advisory committee were set up to deliberate on issues and provide mitigation strategies for the project. These included NEMC who advised on how best the project could be undertaken so as not to infringe on environmental regulations and set standards. This was important as NEMC had to issue the project ESIA licence for compliance before it commenced operations. NEMC had to confirm the projects planned activities kept environmental disruptions on the minimum using field visits. This was especially in view of the limited green space and fragile wetland ecosystem in DSM (Figure 36C). The interaction of stakeholders as illustrated above depended on the BRT activity for which the stakeholder had either the skills, information or concerns that needed to be addressed with the particular task.

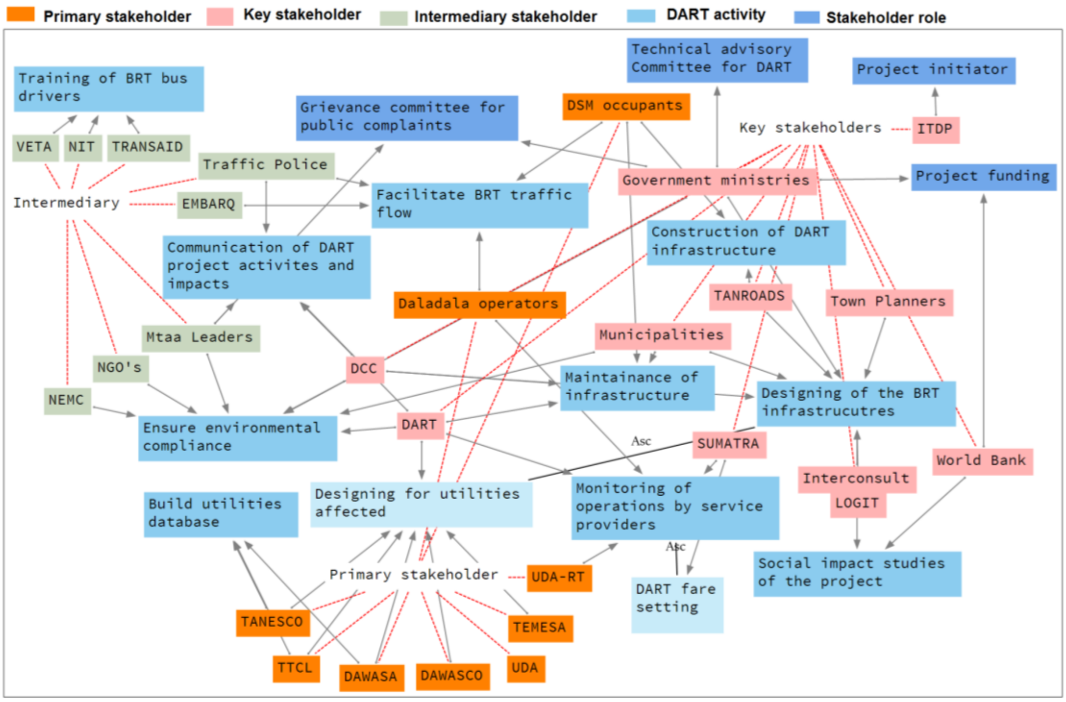


Figure 35 DART stakeholders and activities involved
Source: Research 2016

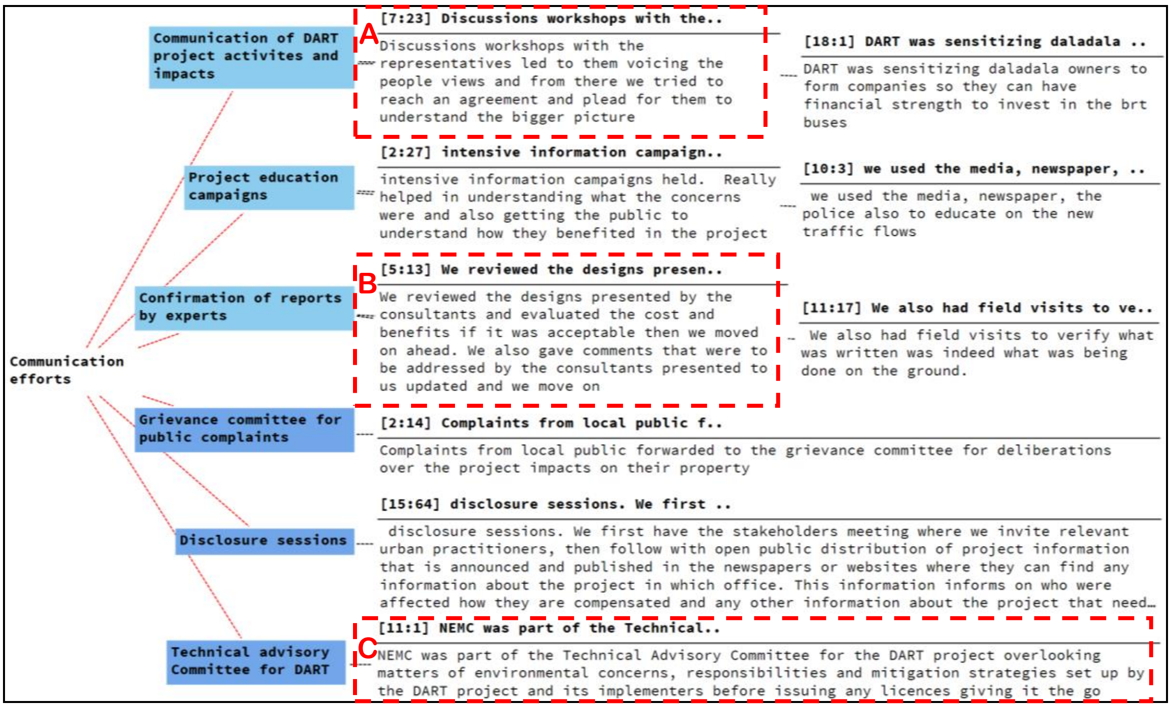


Figure 36 Communication strategies for DART stakeholders
Source: Researcher 2016

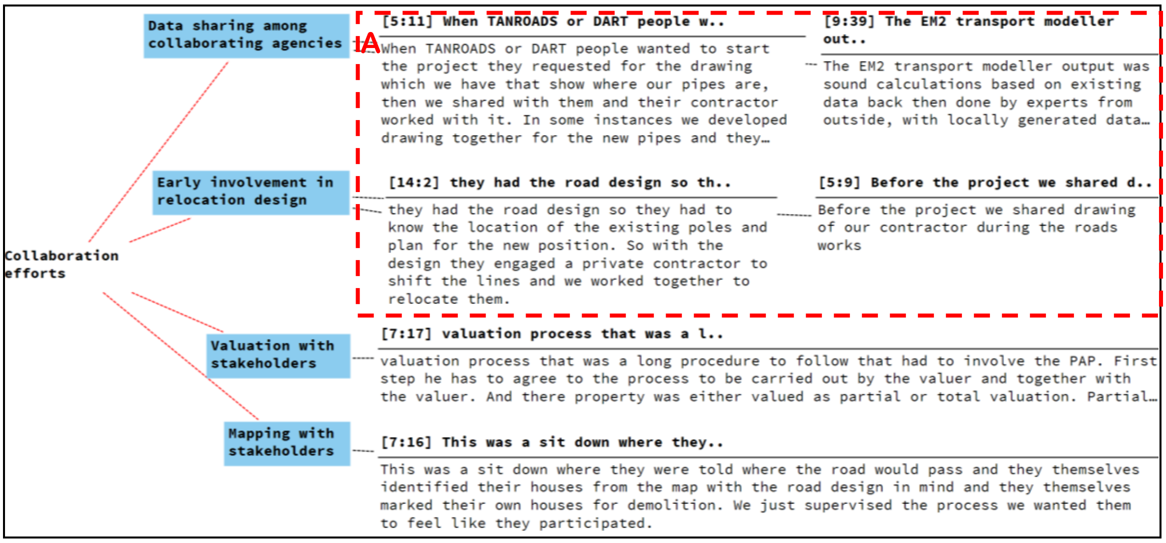


Figure 37 Collaborative efforts in DART planning
Source: Researcher 2016

Though no explicit details were highlighted into to how decision making was done between and among stakeholders, the general take was that decision making with stakeholders in DART depended on the specific task and level of urgency (Figure38). Review board meetings were organised for discussing project requirements and public stakeholder concerns, alternatives and decision making activities. Steering committee members made up of manages and directors from relevant government ministers of finance, housing, transport, local authorities, DART agency officials, grievance committee members, local transportation experts and public transport group representatives formed the major part of the deliberating and decision making body. From this direct description, stakeholder participation mainly involved the agency and agency committee groups. Participation of the public in decision making processes quite limited and their involvement was mainly concentrated on community outreach practices.

"the levels of making decisions, it starts with issues being decided individually, while some are to be concerted to supervisors, others in section or division meetings like the departments, while others are decided by the chief executive officer. Others the chief have to involve in the management team. Also some in the Ministerial Advisory Board and other by the prime minister's office" (DART, Operations Department field correspondent)

Figure 38 DART respondents' description of decision making ladder in DART project
Source: Researcher 2016

The collection of stakeholder information structure by the DART agency identified the stakeholder, their role, expectation and concerns so as to establish the mode of engagement. This provided a structure that made managing the stakeholders relatively easier (Table 5).

Table 5 DART stakeholder analysis task

STAKEHOLDER ANALYSIS						
STAKEHOLDER CATEGORY	**REASON FOR ENGAGEMENT**	**EXPECTATIONS FOR THE PROJECT**	**STAKEHOLDER**	**RESOURCE/MANDATE**	**ENGAGEMENT STRATEGY BY PLANNERS**	**STAKEHOLDER CONCERNS**
Central government	▪ Provide legal, financial and administrative set up to develop the project ▪ overseeing RAP implementation ▪ addressing grievances, technical, legal and policy issues ▪ facilitate property compensation	▪ Improved public transport ▪ successful participatory plan for DART project and RAP ▪ timely executions of activities	Ministry of land, housing and human settlement	▪ Ensure and confirm valuation amount paid to the PAPs is equivalent to the value of affected properties	**Review board meetings**	▪ Uncooperative PAP
			Vice Presidents Office Division of Environment and NEMC,	▪ Environmental Monitoring and Auditing Advise government on all projects impacts on the environment		▪ Lack of compliance to environmental regulations
			Ministry of finance	▪ Facilitate the valuation exercise		Project cost exceeding benefits
			PMO- RALG	▪ Setting operational standards for transportations ▪ Project monitoring ▪ Overall responsibility for resettlement: Provide funds for compensation		Project cost exceeding benefits Political influence limiting the project
			DART	▪ **Facilitate the resolution of disputes among project stakeholders** ▪ Managing resettlement progress and disbursement of compensation funds on behalf of PMO- RALG		▪ Lack of political support ▪ Political interference with the planning process
			TANROADS	▪ **Technical support: construction, and maintenance of DART physical infrastructure**		▪ Conflicting design and construction works
			SUMATRA	▪ **Public transport route service information**		▪ Backlash from daladala sector
Local Government	▪ Facilitating RAP process, ▪ Follow up on deadlines set for relocation ▪ Identify alternative land for relocating ▪ Facilitate project communication with community	▪ PAPs vacate the project area ▪ All PAPs are paid on time ▪ Relocation proceeds as per the agreed procedures	Municipality Authorities: (Land and environment office, Community development Department)	▪ Advice on the implementation of DART project at district level ▪ **Provide baseline data on social economic conditions** ▪ Provide technical support in land acquisition including property valuation	**Public meetings** to inform and sensitize local about DART project, its positive and negative impacts, and their right to be compensated; **Key stakeholder meetings** with leaders collect specific data about the village	▪ Revenue decline from reshuffle of authorities jurisdiction over new infrastructure
			Ward Executives and education officer - Kivukoni, Mchafukoge, Kisute, Upanga East, Upanga West, Jangwani, Magomeni, Ndugumi, Mzimuni, Makurumula, Manzese, Ubungo wards	▪ **Provide information on the local conditions** ▪ help inform the communities to participate in the public meetings		

Project Affected Persons	▪ Vacate affected land as per agreed time	▪ Fair compensation and redirected to alternative land for improved livelihoods ▪ Reconsideration of project to build on vacant lots to avoid business disruptions	retail shop owners	▪ Provision of land for project implementation	**Public meetings** to inform and sensitize locals about DART project, its positive and negative impacts, and their right to be compensated; **questionnaires and interviews** to obtain the views of PAPs **invitation letters to participate in public meetings**	▪ Under-valued and delayed compensation process ▪ **lack of transparency in the process of land acquisition and property demolition on an equal basis-Land/ right of way obtained on equal basis – should have property demolished on all sides of the roads identified**
			street vendors	▪ Provide information for compensation and resettlement factors, and opinions on the project		
			home owner and renters			
			oil station owners, small and medium factories, warehouses owners			▪ Disruption of business functions ▪ **Proposed government relocations sites would be away from existing business areas**
	▪ Relocate service routes	▪ Maintenance of income	Daladala owners	▪ Withdrawal from bus operations along main trunk route	Key stakeholder meeting of with transport agencies	▪ Loss of income ▪ **Relocation to low service demand areas**
Affected Local Communities	▪ Provide support Identify alternative land to host PAPs	▪ Improved socioeconomic conditions and livelihoods of the local communities employment opportunities	Community based organisations	▪ local knowledge on community setting	**invitation letters** Public meetings to inform and sensitize local about DART project, positive and negative impacts, and their right to be compensated; **review sessions of possible sites** for relocation of affected people	▪ project intrusion into space allocated for religious activities ▪ **Strain on limited community resources with new settlers**
Utility companies	▪ Oversee relocation of utility lines	Successful relocation	TANESCO, TTCL, TCRA , DAWASCO/SA	Provide right of way space to BRT infrastructure	Key stakeholder meeting of consultants	▪ Disruption of service to DSM residents

*Information compiled from research field notes African Development Bank, (2015), DART, (2007), (2009), (2014a); Mlambo, (n.d.)

7.4. Phase implementation evaluation

The physical infrastructure of DSM's road network has shaped the service provided. Daladala services have been limited to the predominantly radial road way network of four lane primary roads and two lane secondary roads with majority of DSM serviced by unpaved tertiary roads (Figure 39). Undivided lanes in DSM lead to mixed traffic operations (Figure 40) that cause traffic build up and congestion, affecting public transport service as earlier described (see section 6.2). Not much is provided for non-motorized users.

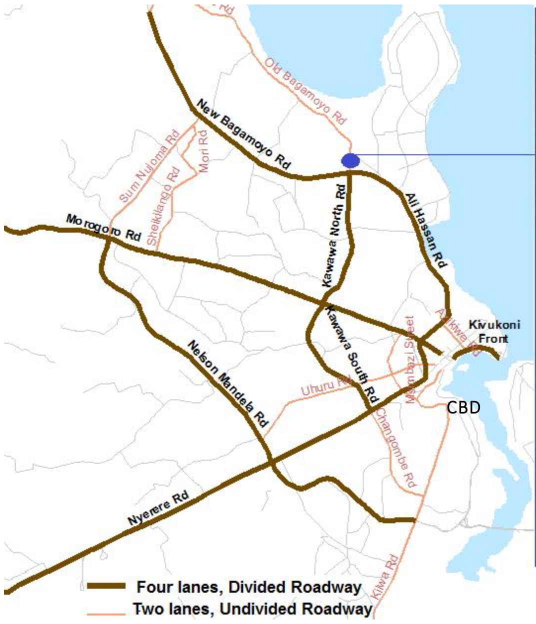


Figure 39 DSM Paved primary and secondary roads
Source: Researcher, 2016

Figure 40 DSM road characteristics

Source: Researcher. 2016

From the time of DART's conceptualization, decision makers wanted the DART system to improve the road network at Morogoro road (see Figure 39). The consultancy of Interconsult and LOGIT, however, insisted on validating the selection of Morogoro before carrying out any detailed designs for the infrastructures. Such an approach was to help define not only current operations but prepare for future plans. The consultants created a multi criteria evaluation process to establish the priority corridors that was modelled in a three level hierarchy (Figure 41). The first level defined the objective, followed by the decision criteria of present transport demand, project feasibility and environmental impacts with sub criteria to investigate a third level tier of alternatives (DART, 2009). To define the evaluation criteria weights, local transport experts were used by the consultants and the demand criteria was set at 51.7%, project feasibility, 27.7% and environmental impact 20.6% (DART, 2009). Reports however fail to expound more on the composition of the transport experts used and the strategy applied that produced the weight values.

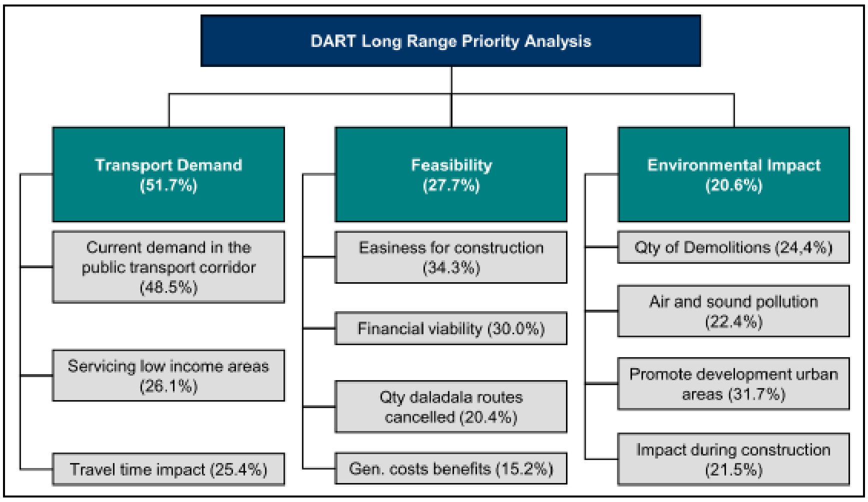


Figure 41 MCA evaluation for corridor selection

Source: (DART, 2009)

Strategic Objectives		Transport demand			Factibility				Environmental impact			
Tactical Objectives		Curent public transport demand on the corridor	Low income demand	Public transportation travel impact	Easiness of implementation	Financial Viability	Daladala routes to be cancelled	Generalised costs benefits	Demolitions	Air and soud pollution	Urban area development	Construction Impact
Alternatives	Analists	0	13	0	13	0	0	0	13	0	12	13
DART 1	Morogoro Rd		7.1		8.5				7.0		8.1	6.8
DART 2	Uhuru / Nyerere Rd		6.3		4.8				4.6		5.9	3.7
DART 3	Kawawa Rd		5.7		7.8				6.3		6.6	6.4
DART 4	Kilwa Rd		8.2		5.9				5.2		6.9	5.2
DART 5	Ali Hassam - Bogomoyo Rd		3.5		6.4				5.5		6.2	5.7
DART 6	Nelson Mandela / Sam Nujoma		4.9		7.1				6.5		5.9	6.3
DART 7	Msimbazi		4.1		3.9				3.7		4.4	3.4
DART 8	Shekilango		5.2		4.0				3.4		5.1	3.7

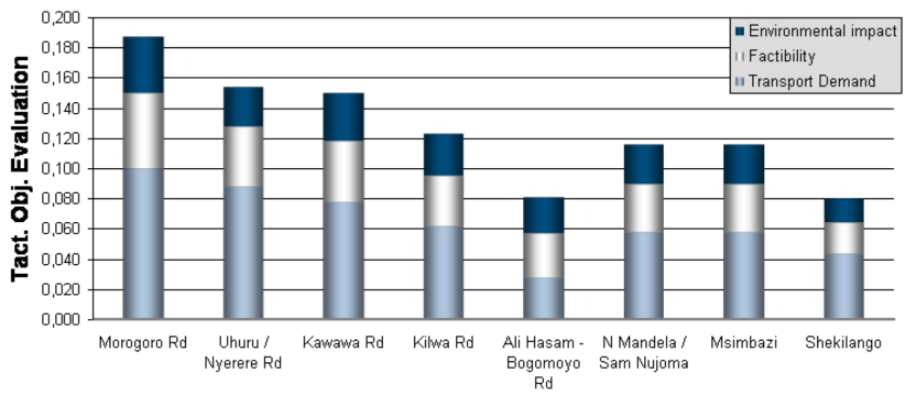


Figure 42 Normalized planners deliberation scores and visual presentation of corridor performance for selection

Source: (DART, 2009)

The criteria structure was then presented to the local planning team with the help of the consultant representatives acting as facilitators. As facilitators they guided the planning team through the process of quantifying their judgment on the potential corridor. Results were standardized to allow for comparison and later presented using a simple chart for visualization and further deliberations (Figure 42). The results illustrated that Rorogoro was the most suitable selection for the initial project corridor satisfying local planners' choice that was objectively made. This manner of decision making for the selection of the corridor was justified through sound evaluation making it an acceptable approach for a transparent planning process. In relation to literature reviewed on SDSS, the approach illustrates a potential in DART for the application of MCDA tools.

7.5. DSM Demand Analysis and Infrastructure Planning

The detailed demand studies by the international consultants LOGIT using the Emme/2 software, and GIS tools provided passenger demand information at peak hours for roads classified as primary and secondary in DSM (Figure 43A). Using GIS, the feasible BRT corridors were easily identified in relation to the city. Further GIS analysis refined data through the selection of feasible corridors with over 4000 passenger demand levels and road infrastructure size with the attributes of 40 meters wide cross section (DART, 2009)

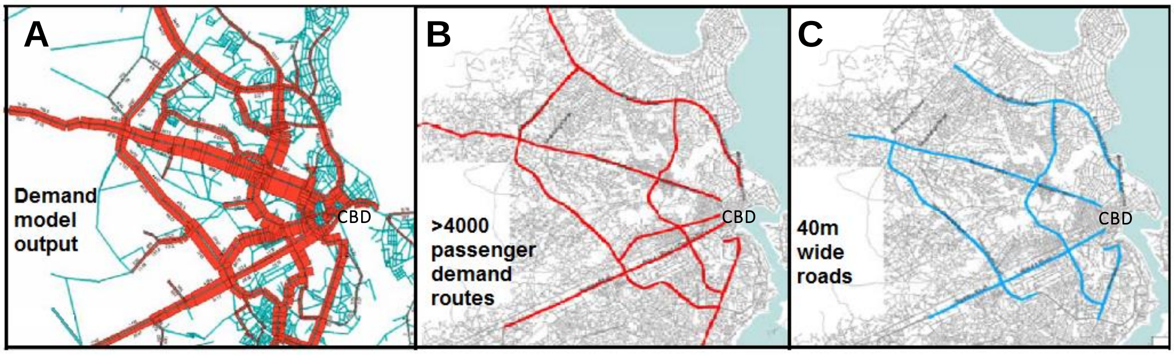


Figure 43 Demand model output and GIS for decision making
Source:(DART, 2007a)

In view of decision problems that might arise on median location of BRT infrastructure, it is this study's view that the information can be useful in identifying the range of trunk corridors that could allow for the optimal BRT infrastructure of two lane busway, two lane traffic lane, pedestrian walkway and bicycle lane for both directions. This information if well-structured in a SDSS can support decision making for site identification for the different sizes of median transfer stations (Figure 44).

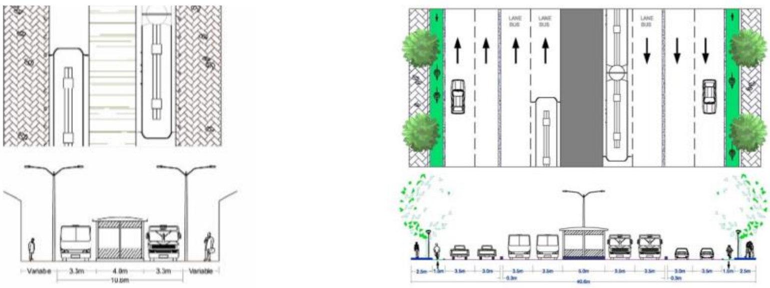
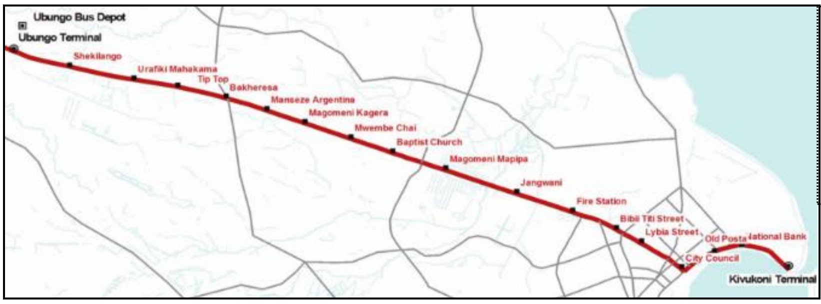
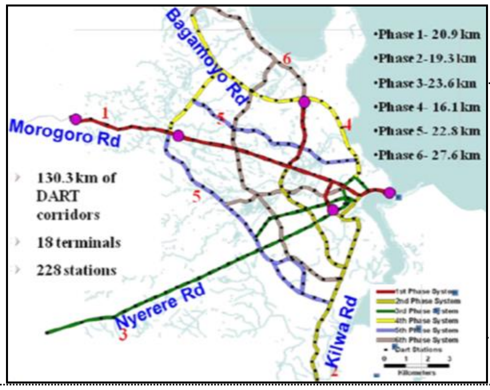


Figure 44 Constricted 10m width to optimal BRT 40m width BRT median station set ups
Source: DART 2007

The demand model also illustrated the influence of intersections to the increase in passenger demand towards the CBD area where the main destinations were the old center of Kariakoo and Kivukoni (Figure 47). This created decision problems for planners. One alternatives was to establish big transfer stations at intersections, and have passengers change routes. Consequently this was to increase their travel time. The other alternative was to extend the network corridors beyond the 10km pilot project, and establish terminals with direct service lines to popular destination. This increased the cost of the project but offered better services (DART, 2007a). During deliberations, the local transport experts advised against having users change routes since it increased their travel time and would not be in line with the BRT vision, while ITDP experts advised on increasing the route length for the BRT to be experienced as a system. Resultantly, designers and planners redrafted the BRT phase 1 corridor to attend to demand and avoiding transfers points that would delay passengers. The political stakeholders agreed to restructure the project from a pilot 10 km stretch to a phased BRT system project (Figure 45)(DART, 2009) .



Pilot project of BRT corridor from Kivukoni to Ubungo as terminal points along Morogoro Road



Full 6 phase BRT system for DSM

Phases	Road Corridor
1	Morogoro, Kawawa North, Msimbazi Street, Kivukoni Front
2	Kilwa, Kawawa South
3	Uhuru Street, Nyerere, Bibi Titi na Azikiwe Street
4	Bagamoyo and Sam Nujoma
5	Mandela Road
6	Bagamoyo Road

Figure 45 DART pilot to BRT system

Source: DART, 2009

7.6. Designing for DART Infrastructure and system integration

The conceptual design for DART's BRT infrastructure was based on a trunk-feeder systems which emulated the concepts applied in Bogota. Segregated lanes and conventional stations located at the center of the road was the design adopted. As described in the ITDP model, high demand routes were selected for the main trunk routes, Morogoro Road, while low demand routes were made to be feeder routes (see section 3.1.1.3). An additional criteria applied for DART was that the selection of feeder routes was to be based on service coverage (Figure 46).

The planner's task was to identify areas where public transport service would be interrupted or made inaccessible by the reorganization of daladala service for BRT. They were to also include areas where there was inadequate public transport services and where ridership could be created (DART, 2007b). This planning activity made use of route information from SUMATRA, daladala companies and municipalities who gathered the opinions from community groups. For phase one, GIS experts, defined the service coverage areas based on the criteria and the base assumptions of using a feeder vehicle capacity set at 50 passengers. During this process, local transport service providers favoured the use of existing daladala vehicle to operate as feeder vehicles, but the final decision was to be made by the DART agency and bus service providers (DART, 2007b). Since the feeder planning process for DART did not develop as the corridor, the study identifies a lack of commitment to plans. Despite the feeder projects offering an alternative to daladala concerns, and consultants identifying criteria and techniques in identifying potential sites, without the commitment of decision makers and other key stakeholders, the information provided is indeed of limited value to the process.

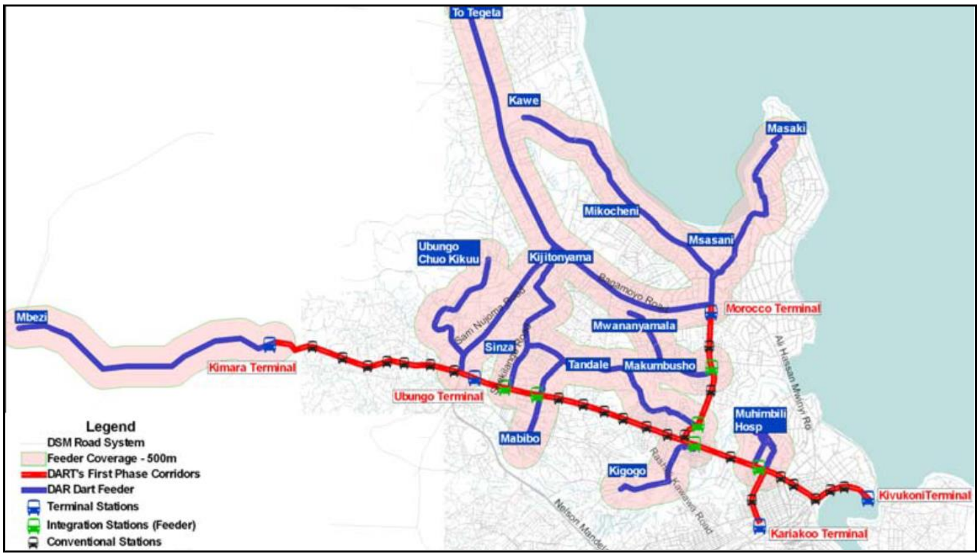


Figure 46DART potential feeder routes

Source: DART 2007b

In the designing for transfer points, information on the intensity of passenger movement observed and the existence of bus stands along the designed corridors and proposed feeder routes was to be used. The indicator for passenger intensity was an occupation index along the routes. This was also in line with the planning for services by creating of demand zones in which the higher the index number the minimum the number of stops to increase performance (DART, 2007b). One of the key physical design features was the DART system to include overtaking lanes at conventional stations and the final design was for DART to have 5 terminal stations, 6 feeder stations and 23 conventional stations (Figure 47) (DART, 2009).

Despite the structured approach location of conventional stations was placed after every 500 meters and of the same capacity size. DIT and City Council stations which were within CBD area were of smaller size due to the lack of space. The few feeder stations built serve as taxi and motorcycle stands while some of the conventional stations where passenger movement is high is obstructed by local vendors and vehicles who use the constructed walk ways for parking.

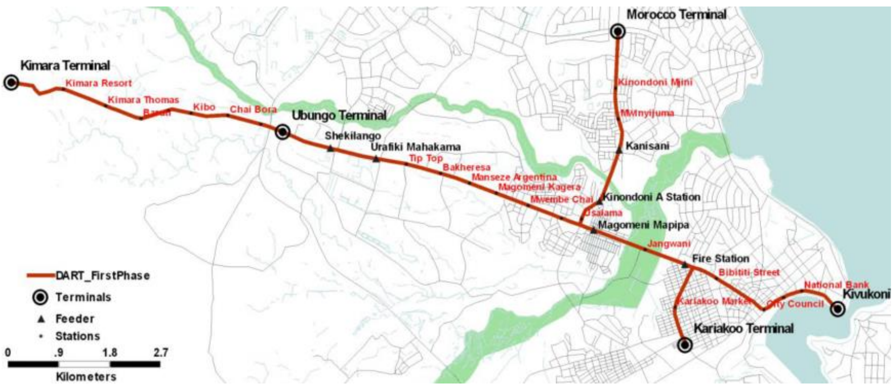


Figure 47 DART design for stations and terminals

Source: DART, 2009

In the planning tasks for terminal location a major consideration was on the potential of the terminal site developing into viable commercial zones. DART planning considered the terminal sites as primary sites for relocation of street vendors as an attempt to address street and road side hawking. Resultantly the planners had to identify spacious areas that could offer vendor space in addition to being a site located along the corridor for the terminals to serve the system with uniform demand. This demand consideration was important so as to avoid empty buses operating in between other stations (DART, 2007a). Using an evaluation matrix, consultants and local transport experts made a link between service and location using O-D information. Location of the terminals were compared to justify the potential of service lines and also estimate terminal capacity based on the passenger travel behaviours (Figure 48). The final decision's criteria was however based on locations already being natural passenger transfer points with high concentration of transit lines (DART, 2007a).

O\D	Ubungo	Morocco	Kariakoo	Kivukoni
Kimara	N	x	x	x
Ubungo		x	x	x
Morocco			x	x
Kariakoo				N

X Potentially useful, direct service line
N Not enough demand for direct service line

Figure 48 Service matrix comparison between terminals
Source (DART, 2007a)

The planning for depot locations was the most challenging infrastructure due to the amount of space that was needed. A major factor being the lack of an updated spatial guiding development plan for the city (Figure 49). DART's depot, similar to the planning guide description, had to include on the minimum paved parking areas for the BRT buses, the office buildings, and the maintenance work-shed (DART, 2009). Initially, two depot stations were to be set up starting with one at Ubungo upcountry terminal bus area that was near the Ubungo terminal. The site was suitable since it was already being utilized by long distance travel companies that made the available land identified to be of less conflict in relatin to land use activities (DART, 2014a). The second depot had three potential depot sites identified for evaluation based on the criteria outlined in table 6. The sites were University of DSM (Figure 51), Biafra area (Figure 52) and Kariakoo terminal (Figure 53) (DART, 2007b).

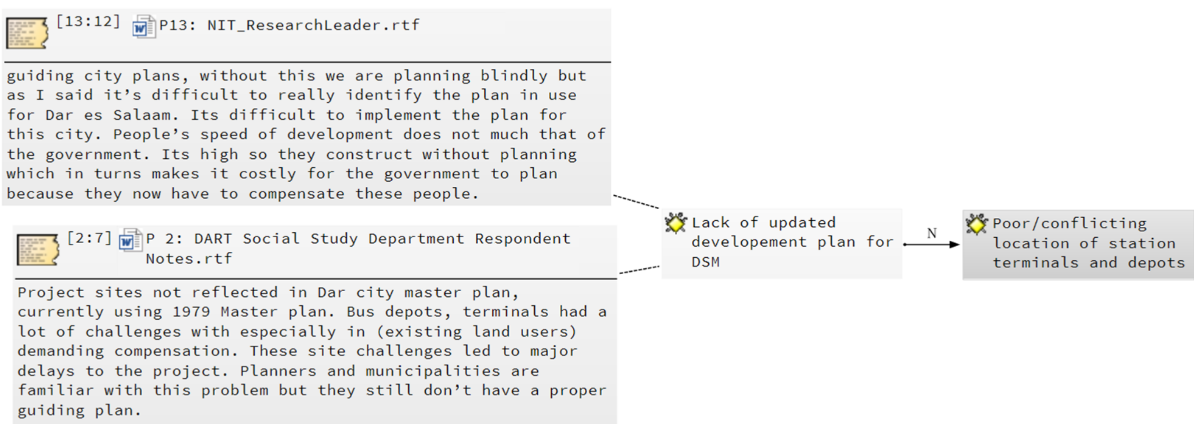


Figure 49 Respondents comments on challenges of spatial planning
Source: Field research, 2016

Table 6 Criteria options for location of BRT depots

CRITERIA	
+	---
Surrounding area is already used for similar proposes	Area prone to legal dispute over ownership
Medium to low environmental impacts	Requires significant earth movement
Good location in proximity of a corridor branch	High social impact
Favourable topography	Requires widening route improvements for accessibility
Availability of required space to accommodate the fleet of one bus operator	Land use conflict with noise sensitive impact receptors like schools, hospitals universities
Good accessibility for the articulated buses	Requires significant earth movement
Reduced social impact (no need for resettlement)	

Source: DART, 2007

For the Ubungo site the possible relocation of some country bus companies was highly contested by the country bus companies. This situation was accelerated by power wrangles within the municipalities in relation to the relocation of the country bus terminal which was associated with loss of revenue collected from the bus operations (Figure 50)

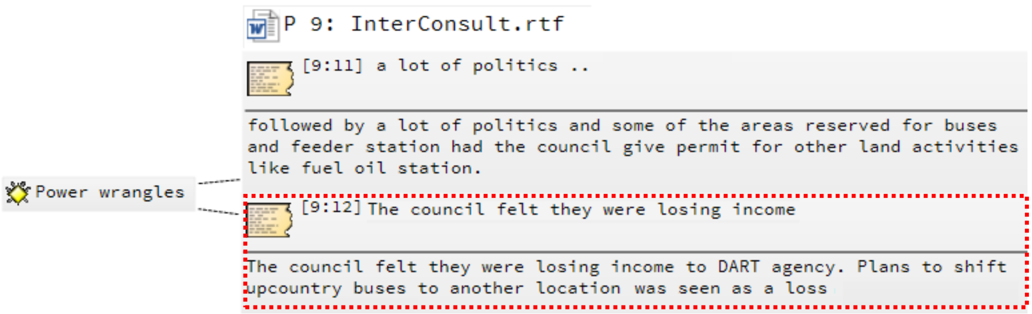


Figure 50 Interconsult, project designer response on depot site identification problems

The other potential sites in relation to the criteria fell short. The site opposite the university was disconnected from the main corridor which meant bus operators would experience dead kilometres (Figure 51). The increase in distance between the bus depot to the start of a service or end of the service to the depot is unattractive to service providers as explained earlier in section 3.1.2.

Figure 51 Potential depot sites to opposite DSM University
Source: Researcher, 2016 , Google earth imagery date 2016

The Biafra site, having established itself as a recreation site for the surrounding community led to public resistance to its conversion into a bus depot. This presented the challenges to acquiring the land for depot development (DART, 2007b)

Figure 52 Potential depot site at Biafra near Morocco terminal
Source: Researcher, 2016 , Google earth imagery date 2016

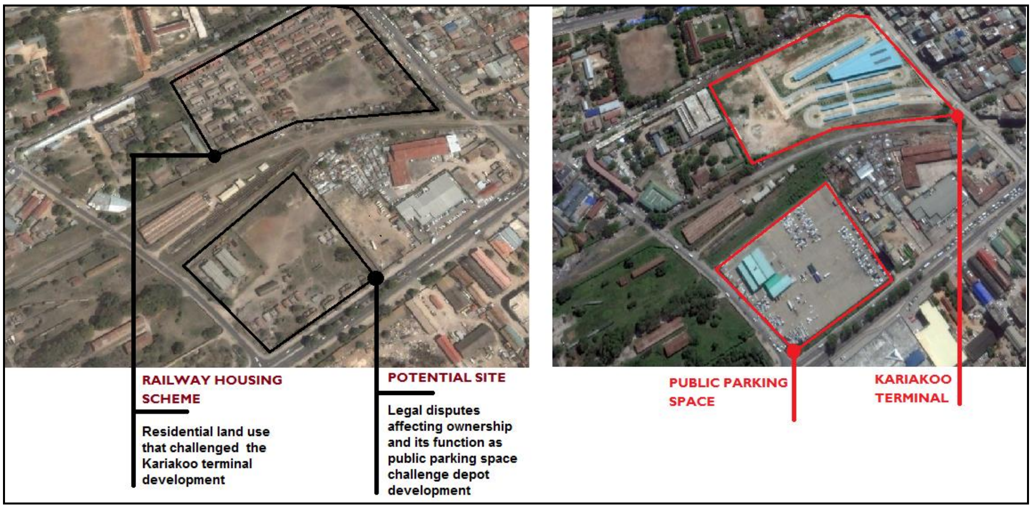


Figure 53 Potential site near Kariakoo terminal
Source: Researcher 2016, Google earth imagery date 2004 and 2016 respectively

For the Kariakoo site (Figure 53), land dispute over ownership made it difficult for DART agency to negotiate land acquisitions in favour of a depot. The area in turn developed into a fully-fledged public parking space (DART, 2007b). Since DSM has challenges in the amount of parking space available for the city, the setting up of a bus only depot was met with resistance from car owners. On the up side the parking space offers park and ride characteristics that could potentially improve and maintain system ridership.

Due to these challenges in identifying suitable sites and a need to establish a depot for the commencement of the first phase of DART, a government directive led to the development of the first depot within Jangwani wetland area. This led to oppositions with the environmental authority NEMC and local NGO groups Lawyers' Environmental Action Team (LEAT) who presented their concerns to NEMC protesting the construction of the depot. The Jangwani wetland due to DSM limited green space, is vital and functions also as a natural drainage to the city's flood waters. The depot conventional station was decribed to be a relative waste of limited resources since its location service area was lacking. In addition, its location was seen as a potential influence to increased squatting within the wetland that was already a challenge being faced by NEMC (Figure 54).

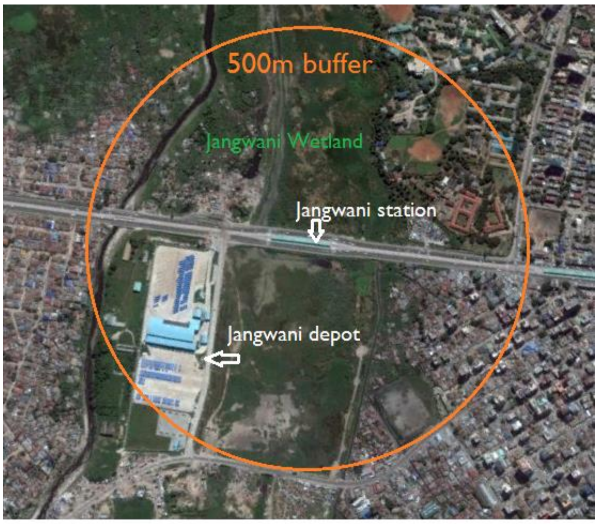


Figure 54 Depot and station location within Jangwani wetland area
Source: Researcher, 2016; Google earth imagery date 2016

Decisive top led decisions

[9:13] P 9: InterConsult.rtf

Jangawani also raised a lot of complaints as it is a flood and open area and no one is/ was supposed to be there but the president gave an order and had the final say

Lack of commitment to development plans

[11:19] P11: NEMC.rtf

I was dissatisfied because the construction at Jangwani was done despite in relation to our office and comments it was always raised that it should be relocated but government and some politicians had the last say

7.7. Reflection on DART infrastructure planning

Reflective look at the DART planning process illustrates a fit to BRT activities as defined in the ITDP model. Scenarios similar to Bogota's transport system prior to the BRT (see 4.1) are observed. Bus operators dominate the transport sector and the public transport users are vulnerable to the whims of bus owners. Administratively, the responsible authorities and traffic enforcers are weak in their capacity to control the bus drivers and owners unruly road behaviour. Irrespective of attempts to revive rail related commuter services deeper administrative restructuring and priorities need to be aligned for expected levels of sucess. Spatially the transport system serves to move people from the residential areas into the city, with outskirts occupied by low income groups. Differences however are that DSM lanes are either paved or unpaved lanes with no special consideration for buses. In addition road infrastructure classification is based on administrative levels. In regards to this later observation, it can be plausible that DSM should have considered the TRB model to some extent and planned the system in relation to the integration of its road hierarchy structure. Being a port city, the integration of its transport networks could have improved the city's economic chances at a relatively larger scale than the restructuring of the paratransit business scale presented by the ITDP model. In considerations of the initiators of the project, ITDP and UNEP, it is assumed that the ITDP model was their set conditions.

Despite not being in the mayor's political agenda unlike Bogota, the strategy used by ITDP agency in approaching a local NGO involved in mobility issues to present the BRT proposal to the local government is considered by this study a positive approach that might have contributed to the acceptance of the project. This approach has the potential of integrating the concept of BRT in areas where non-motorized mobility practises are emerging. By securing the mayors support, who used his influence to secure government support the political backing needed for the project, as stated in ITDP model was set. But just like Bogota's mayor had control over the lead agency activities, DART agency was to be under DSM Prime Minister Office and later the president's office when government's structure changed. This level of control by a political figure under the name of political insulation is considered a main cause of the relative ease in top down decision making that is associated with BRT infrastructure selections. Especially in the planning process for BRT corridors. Similar to the selection of TransMilenio's first corridor by the mayor, political decision makers in DART wanted the BRT corridor project along the Morogoro road (see

6.2). The basis was because it was the busiest route in DSM from local experience. But unlike TransMilenio the consultancy Interconsult/LOGIT insisted on the demand studies which formed an important base of the entire planning process for DART. The consultant's strategy in structuring a quick, transparent multi-criteria evaluation process (see Figure 41) that engaged local transport experts and the planning team to justify the corridor selected provided a channel for the executing of the demand studies.

The outputs illustrating the demand and potential of a full system in Dar with consultants' advice, public consideration by planners and the DART vision of access for residents, is assumed to have contributed to the conversion of the pilot project to a full system. This observation though is stated with reservations on the basis that the second and third phases set to begin construction are coincidentally main roads for the two municipalities of Ilala and Temeke. Matters of demand and access are assumed to have been set aside for the political agenda of territorial appeasement. This perspective is made due to the feeder project of phase one that was to cater to the population affected by the cancelation or redirecting of routes being neglected while the project moves on to the next phases.

On the tools and techniques applied in decision-making there is use MCDA in the form of cost benefit analysis. This was applied amongst stakeholders within the technical advisory team that constituted TANROADS, DART, Interconsult/LOGIT. Since they had to identify mitigation strategies by the project they provide groups with potential information on indicators for SDSS criteria factors. They could also be users of the SDSS in evaluating different mitigation strategies they propose. The use of matrix system of evolution options as was applied in terminals (see figure 48) offers a possible application of AHP matrix (see Figure 9) to compare judgements during decision making. Demand analysis for this study is stated to be a prime source of information a SDSS could utilise since decisions made in the DART process should be based on the demand results. In tasks where criteria are already provided like stations, terminals, and depots, the information can provide focus on the type of geographical data that could be used to build a GIS database.

An important note for the SDSS design for DART is that it should be should be flexible since its decision making process is flexible (see Figure 38). Flexibility enables it to be used in both small group setting of collaborative decision making amongst departmental deliberations to the broad setting of an advisory and multi-disciplinary meetings.

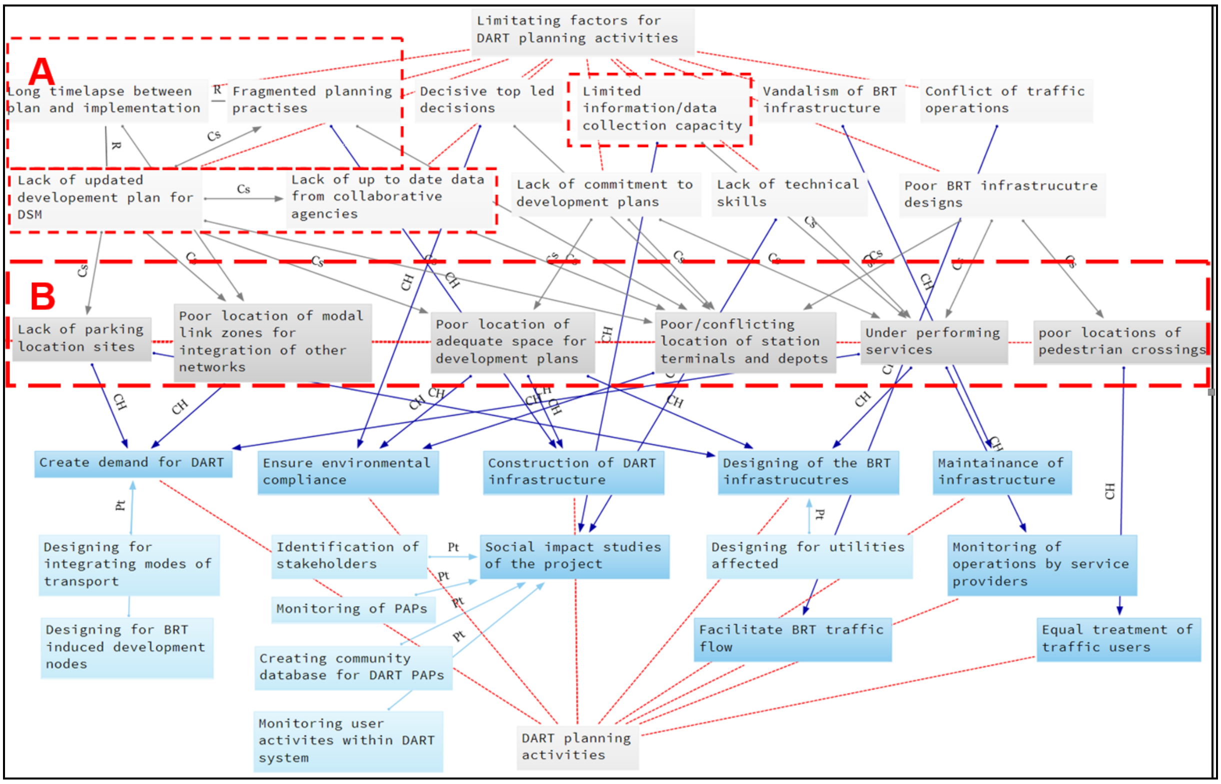


Figure 55 Limiting factors to BRT planning

From the study, factors that led to the emergence of spatial decision problems (Table 7) in DART infrastructure planning resulted from the primarily, the lack of an up-dated physical development planning guide (Figure 55A). Planners in the project had to work with the outdated master plan of 1979 (DART and NIT respondents). The development within the city has been a fragmented one and as a result there is lack of quality data from other planning agencies and stakeholders that limited the potential of collaborative efforts.

Spatial problems for BRT have included poor location of infrastructure, leading to under performances of the system and conflict between transport related land-use like parking. (Figure 55 B). Without sufficient data and information for stakeholders to use in the decision making process, planning with their considerations are challenged in terms of reliability of the outputs. For a SDSS tool and application, lack of up to date data is a major barriers.

Table 7 DART Spatial decision problems

Planning task	Spatial Decision problem	stakeholders	Decision making tools/strategies
Corridor selection	***Selection of type of BRT solution-*** ▪ Implementation of pilot corridor along popular route ▪ Run demand analysis to select corridor for pilot project	DART planners, Interconsult/LOGIT design and demand modelling consultants Political representatives, Road agency SUMATRA	Political directive Multi Criteria evaluation MCA Demand analysis results Emme2 - GIS
Network coverage extent	***BRT characteristic*** ▪ Standalone pilot corridor improve trunk corridor ▪ Transfer stations at major intersections increasing travelling cost ▪ Extend corridors reducing traveling cost	DART planners, Interconsult/LOGIT design and demand modelling consultants Political representatives, Road agency SUMATRA, Local transport experts, ITDP	GIS maps, Demand analysis maps

	▪ Extend corridor increase project cost ▪ Extend corridor implement full trunk and feeder coverage of areas with high demand ▪ Relocate daladala to alternate routes to serve as feeder service providers ▪ Cancel daladala routes feeder bus for BRT feeder bus	experts, TANROADS, paratransit representatives, municiplaites, Dar city council	
Network design	***Selection of sites*** ▪ Adjacent location of depot and terminals existing country bus site ▪ Relocation of country bus site for DART depot ▪ Location of depots and terminals on available space away from corridor ▪ Compensation of property owners to obtain land ▪ Design on spacious ecologically sensitive landscape	DART planners, Interconsult/LOGIT design and demand modelling consultants Political representatives, Local transport experts, TANROADS, paratransit representatives, Municipalities, country bus companies, business community,	GIS maps Cost benefit analysis
System integration	***Selection of sites*** ▪ Allow use of space for car parking near terminal ▪ Compensate property owner for space for depot near terminal	DART planners, Interconsult/LOGIT design and demand modelling consultants Political representatives, Road agency SUMATRA, Local transport experts, ITDP experts, TANROADS, paratransit representatives, municipalities, Dar city council, business community	

7.8. Spatial Decision problems in BRT Planning

Table 8 Spatial decision problems in BRT planning

PLANNING TASK	ITDP	TransMilenio, Bogota	DART, Dar es Salaam
	SPATIAL DECISION PROBLEM		
Corridor selection	*Selection of type of BRT solution-*		
	▪ part time bus lanes without physical segregation,	▪ Implementation of pilot corridor in less congested routes	▪ Implementation of pilot corridor along popular route
	▪ segregated median busway with double bus lanes at overtaking stops,	▪ Design of full BRT system in bus congested corridors	▪ Implement demand analysis select corridor for pilot project
	▪ full segregated double busways with one or two other close supporting corridors		▪ Trunk-feeder or direct service lanes (Relocate or cancel routes)
	▪ Trunk-feeder or direct service lanes (Relocate or cancel routes)		
Network coverage extent	*Selection of BRT characteristic*		
	▪ Limited pilot coverage along major trunk corridor save costs	▪ Standalone pilot corridor	▪ Standalone pilot corridor improve trunk corridor
	▪ Extensive network along several trunk corridors increasing cost	▪ Full coverage of city in areas of high social vulnerability	▪ Extend corridors reducing traveling cost
	▪ Coverage in areas of high social vulnerability increasing accessibility	▪ Full coverage in all parts of the city	▪ Extend corridor increase project cost
	▪ Coverage in all areas increase ridership		▪ Extend corridor implement full trunk and feeder coverage of areas with high demand
Network design	*Design solution*		
	Corridor space		
		▪ Provide BRT tunnel and increased project cost	
		▪ Acquire property and increase in project cost	
	Transfer points		
	▪ Single or multiple station bays	▪ Adjacent location of depot and terminals at end of trunk corridors	▪ Transfer stations at major intersections increasing travelling cost
	▪ Station site spacing on demand or after fixed distance	▪ Location of depots and terminals on available space away from corridor but close to terminal	▪ Adjacent location of depot and terminals existing country bus site
	▪ Adjacent or distant location of depot and terminals	Location of depots on available space away from corridor but close to terminal	▪ Relocation of country bus site for DART depot
			▪ Location of depots and terminals on available space away from corridor
			▪ Compensation of property owners to obtain land
			▪ locate depot along-side corridors
	Utility lanes		
	▪ Total or partial relocation of utility lines		
System integration	*Integration options*		
	TOD		
	▪ Park and ride facilities or TOD activities		
	Bicycle lanes		
		▪ Provision of cycle lanes for short neighbourhood distances	
		▪ Provision of cycle lanes for entire BRT lanes	
	Parking		
			▪ Allow use of space for car parking near terminal
			▪ Compensation of property owners to build depot

From the in-depth review of the ITDP model of the BRT planning process, the TransMilenio case and the DART project, it is observed that spatial decision problems vary as indicated in table 8. In corridor selection, the spatial decision problems can be summarized as relating to matters of either developing pilot corridors or full-trunk and feeder systems This further considers if it should be on congested or not so congested roads in the city, and if the choice should be determined by using both a decision tools and local judgment or directly stated by decision makers. Network coverage decision problems relate to the extent of the corridors, to either maintaining system ridership, providing access possibilities for the vulnerable or limit the extent due to the cost of the infrastructure.

For the network design, spatial decision problems, related to the location of depots and terminals. The ideal setting is for them to be adjacent to each other as previously discussed, but due to lack of space options included locating them on available space away from the corridors but close to a terminal, on existing long distance bus depots, or locate the depot along the corridor and away from terminals which DART planners did.

System integration decision problems varied the most. ITDP noted the trade-off challenges between TOD over park and ride facilities. Bogota's decision problems related to the bicycle paths while DART related to trade-offs problems between depot bus parks and car parks near the terminals.

With this insight on the spatial decision problems in the specific planning tasks of BRT planning, a SDSS that fits in a decision making process can be developed.

8. CONCEPTUAL DESIGN OF BRT-SDSS FRAMEWORK

8.1. Conceptual DART-MCSDSS Design

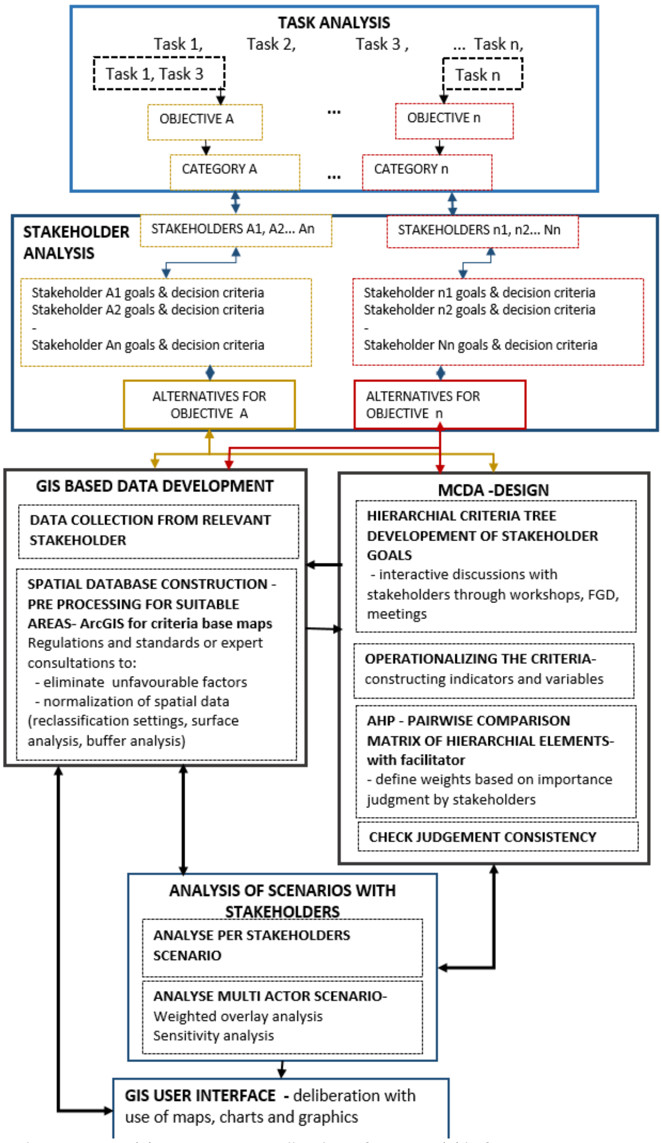


Figure 56 BRT MCSDSS application for DART infrastructure planning

The conceptual BRT-MCSDSS framework presented in this study adapts common practises illustrated in planning with stakeholders for an improved decision making process. The structure of the MCSDSS (Figure 56) is for an open design for project leaders. The framework's principle is to support decision making for tasks with common objectives. The rationale of the design is that infrastructures in BRT are diverse and managing the decision making process for each could be daunting for managers especially when multiple stakeholders are involved. Therefore, by identifying infrastructure planning tasks that have a common objective, the decision making process becomes relatively manageable. The classification in relation to objectives is assumed to help focus the task and improve the efficiency and systematic management of the decision-making process (Mota et al., 2009). This approach could consequently lead to achieving other related objectives in the planning process.

In the case of BRT, an infrastructure planning tasks, can either be the location planning of the main corridors, stations, depots, terminals, feeder stations or routes. The decision making for each task with stakeholders can be time consuming and daunting. But if common objectives are identified, for example the identification of a suitable infrastructure site, or the identification of optimal line operations, or identification of TOD zones. The decision making process becomes relatively easier to manage. The open nature of the BRT-MCSDSS allows the factors within it to be adjustable to the specific criteria and weights of any specific infrastructure with a similar objective (Ruiz et al., 2012). This ability to modify different criteria for planning tasks also supports the iterative nature of the decision making process.

The processes of identifying tasks that can be categorized according to a common objective and stakeholder analysis in BRT-MCSDSS is a pre-requisite activity to the tools application. Stakeholder analysis is important as it helps to identify and align the goals of relevant stakeholders in relation to the main objective. This process is carried out by the researcher to prepare the tool for stakeholder use and is refined during the application of the tool with stakeholders. In addition is the identifying of the base data that will reflect stakeholder information.

In the stakeholder's deliberation sessions, information on alternatives emerge that can be used to identify the common and conflicting objectives and relevant spatial data that can be utilised in deliberation. This information is also used to set up a hierarchical criteria tree that evaluates the goals of the stakeholders. The application of the AHP tool (see Figure 9) to determine the weights based on stakeholder judgments of importance needs to be well facilitated by independent experts and other groups who can act as mediators during the process. Operationalizing of the criteria which involves identifying spatial indicators that measure the contribution of an alternative to a specific criteria can be obtained from stakeholder consultations or literature on regulations and standards (MacHaris et al., 2012). This information also builds up GIS related data. Comparing alternatives in relation to a criteria can utilize automated spread sheet programmes executed by the facilitator but as developed with the group. This improves the transparency and deliberative nature of the decision making process with stakeholders. At the same time recording of the deliberation session allows for information gathering on the decision making process in BRT planning. This can be used to refine the tools application, information and structure for an improved process. Ranking of the criteria are defined and the results of the pairwise matrix integrated with GIS data. The visualizing of the weighted scenarios of stakeholders opens the process for more in depth deliberation and solution development in converging the alternatives generated.

To place the design framework in context, the following section presents the potential application using the case of DART. Important note is that the application is subjective to the researcher's knowledge obtained from the field and literature as analysed in the study. As such it describes how a real process could be done in applying the BRT-MCSDSS for BRT infrastructure planning.

8.2. BRT-MCSDSS application in DART planning process

8.2.1. Identify SDSS need

In relation to stakeholders and the tool's applicability, the study infers that there is potential for the application of the BRT-MCSDSS in the planning process since GIS and MCDA techniques and tools have been utilized and appreciated by the stakeholders (Figures 41 and 57). An underlying principle of the study is that the tool is applied to fit a planning task where a need for the tool has been identified. As illustrated from the previous chapter, BRT planning has several spatial decision problems within different planning tasks. Each task has a potential to utilize a SDSS, but knowing the objective to be achieved for a particular task can lead to the application of an appropriate SDSS tool. This review illustrates an approach to identifying the need for SDSS tool.

In the case of field stakeholder engagement, a closed ended questionnaire used to gain stakeholder opinion on planning activities that could benefit from a SDSS tool can be used to identify where there is a need. By using SPSS descriptive analysis and frequency tables (see annex 10), the mean of stakeholder opinions to identify an activity they think would benefit from a SDSS application can be identified. For this study the DART stakeholder responses means were within a point reach of each other, and with the use of the frequency tables to summarize the needs levels for each activity not much deviation was observed among the individual activities and the high need for SDSS (Figure 58A). Reason for this is attributed to the concept of SDSS being new to the respondents. In addition, stakeholders having prior appreciation for the role of GIS design might accept the concept as being of potential importance to BRT decision making process.

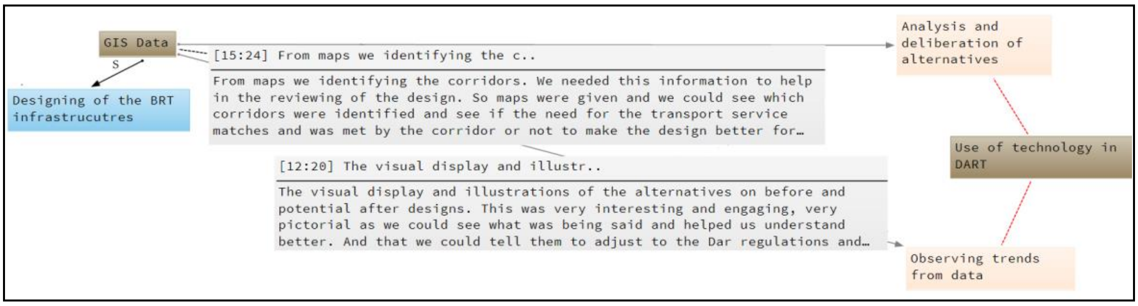


Figure 57 Respondents view and application of GIS related application

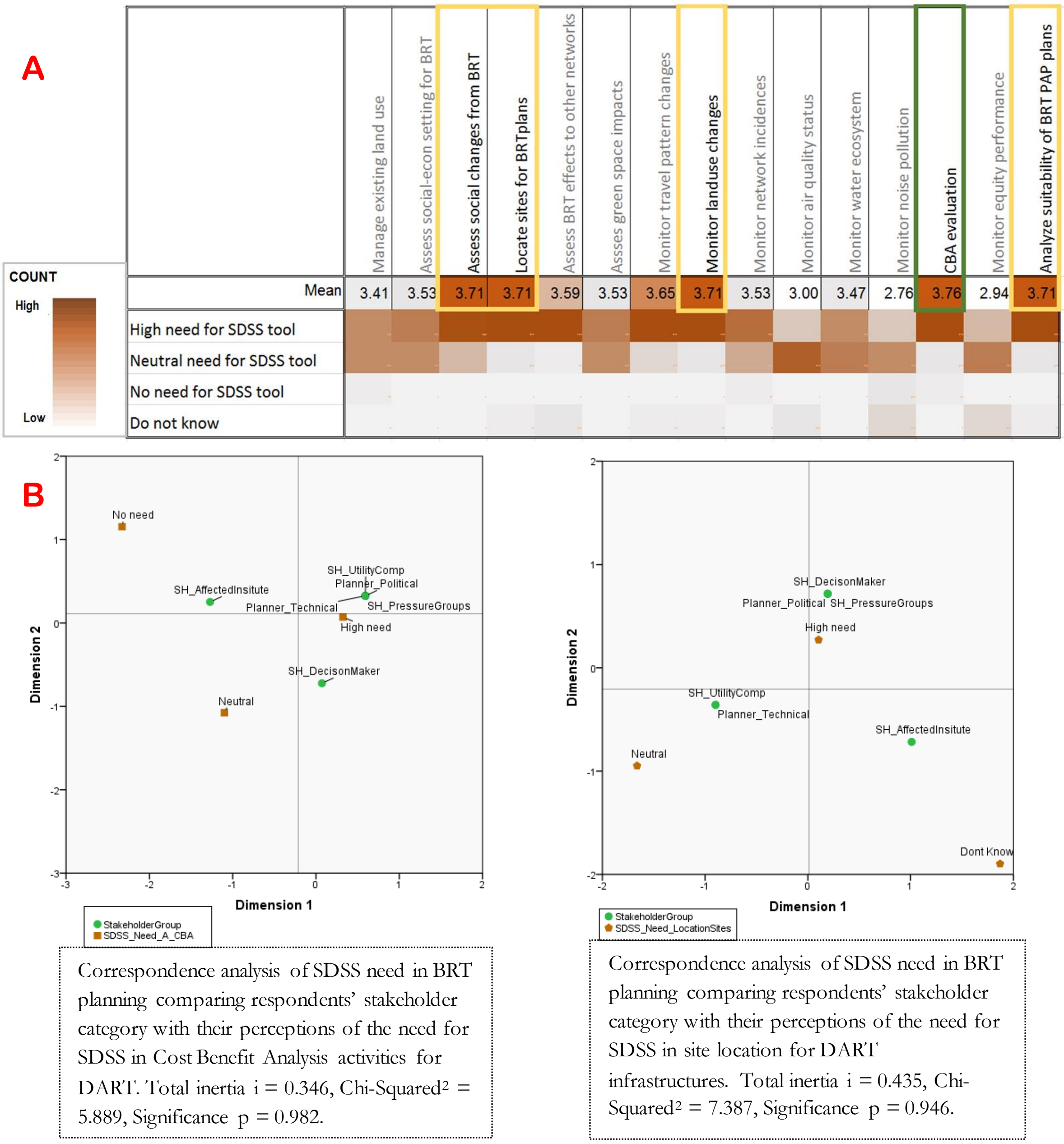


Figure 58 Descriptive mean and correspondence analysis of SDSS needs from DART stakeholders' responses

In order of rank, the highest need for SDSS was in the facilitation of decision making process with factors of cost benefit analysis. This reflected the effects of the projects dependency on loans and grants. With local financial resources being limited, matters of finances were of at most important. In relation to spatial matters, the tool was viewed as having potential in supporting matters of relocation of project affected people PAPs, land use changes, social changes and locating sites for BRT plans. The study views that lack of an updated physical development plan to guide planning activities in DSM, made the spatial support capabilities of a SDSS in locating and monitoring sites suitable for DART infrastructure planning from the stakeholders perspective.

While descriptive analysis are useful, identifying the need should also ensure a level of consensus. Consensus checking for the opinion of SDSS need in BRT can utilize SPSS function of correspondence analysis (Figure 58B). From the analysis, the null hypothesis was that the nature of the stakeholder groups would not influence the perceptions over the need for SDSS tool in BRT planning activity. (Plotting of stakeholders in the row and SDSS needs in the column). Since the results proved statistically insignificant for all activities, definitive explanations of the trends could not be stated. However, the outputs provided visually easy to understand representation of the grouping of the data in relation to the SDSS needs (Prouty et al., 2016). Consensus was high in relation to CBA with relatively low variance of 34.6% compared to variance score of 43.5% from site location opinions and 51.1% of relocation sites for PAPs. While there is optimism for the possibilities of using technology, reluctance of actual application in technology use in the complex political and social structure for DSM's physical planning plan is assumed to be a reason for the variance of SDSS application in site location. This observation however is stated with caution and a more comprehensive stakeholder sample frame would improve the findings. Either of the two approaches can be used in identifying a SDSS need in BRT planning. The literal approach is data intensive but less costly while the latter approach is a source for rich information but costly.

All factors of analysis considered from the planning process reviewed and respondents' opinions, issues of cost and site location were key stimulators of decision problems in DART. The lack of proper spatial guiding resources, justifies the development of a SDSS supporting the decision making process for identifying suitable sites for BRT transfer points.

8.2.2. Task and Stakeholder Analysis

Planning for transfer points can include activities for depots, terminals, conventional stations, and feeder stations. This study application was limited to conventional stations due to data limitations. The criteria however are set for the optimal station identification criteria to enable and infer the inclusion of possible terminal sites. With the common objective set at the identification of suitable location sites, key stakeholders as obtained for the study review are as shown in table 9 together with their specific objectives in the decision making process. Specific objectives collected through administering of questionnaires or workshops would provide refined classification.

Table 9 Stakeholder objectives in planning tasks

PLANNING TASK	STAKEHOLDERS	OBJECTIVE IN DECISION MAKING PROCESS
Locating suitable Sites for Stations	DART agency,	Median, spacious location for BRT identity
	TANROADS, Interconsult	Infrastructure location within existing road spaces
	Government, Local authority, DAWASCO (Utility company)	Minimum distraction to existing infrastructure structures
	Community groups	Location caters to vulnerable in society
	NEMC environmental groups	Site selected are clear of fragile ecosystems

8.2.3. Developing weights and GIS factor maps

In the case of DART's station site location TANROADS, DART, NEMC, government, community groups and utility companies were considered key stakeholders. Real case application calls for lead agency DART to set up a deliberation session. But since they too are participants, they should task the design consultant who partners with research institution to facilitate the process.

The stakeholders develop the hierarchical criteria tree and the weights using the pairwise comparison matrix application that is facilitated by the consultant (Figure 59). For calculation refer to section 2.2. Main objectives of each stakeholder group are presented to the deliberation group and their importance weighed against key objectives of other stakeholders. It should be noted that the interests of stakeholders cut across all other factors and are not exclusive i.e the government can have interests in environmental, community and infrastructure factors but for a particular task objective based on a particular judgment matters of cost can prevail and be of higher importance for their interest and objectives.

Building the criteria tree is iterative and is done for all stakeholder visions (see annex 10). The judgement scores are then assigned and weights calculated. An approach can be a voting system with final tally standardized to the judgements scale. The weights assigned should be clearly displayed for all to see and GIS experts involved to identify and record, from the deliberations, spatial criteria indicators and develop the factor maps as agreed by the group (Figure 60)

This stage as applied in this study used the literature and interview data. Since matters of compensation were of importance to the process and overall responsibility fell on the government, matters of cost was of highest importance and ranked first. TANROADS being project implementers without whom the project construction would not happen ranked second with marginal difference from the government. This is because they factored in matters of cost and limited the construction of DART infrastructure within existing road transportation zones.

Operationalization of the criteria utilized information from stakeholders, project standards, environmental and organizational regulations and available data within the database. For the case of DART, data used included mostly vector data of land use, population, roads, rivers, buildings and commercial key points. Since the data was collective for Tanzania and DSM, selection by location was performed for used vectors to build a database specifically for DART infrastructure. This included the use of ESIA and project appraisal documents, to identify names of the existing roads marked for DART corridor. Geo referenced maps were used to guide the identification proposed station location and the study area boundary (AOI) formed by the DSM wards that have existing and proposed DART corridor infrastructure. All the datasets were uniformly projected and their respective raster and reclassification data set to 30m x 30m within the extent of the AOI. Spatial data representing the factors of the study were normalized using ArcGIS conversion and spatial analyst' tools of To Raster, and Reclass respectively where needed. Normalization was set on a seven step scoring scale with 1 as highly unsuitable to seven, highly suitable. Details of the indicators developed are explained below for each factor.

PAIRWISE COMPARISON MATRIX (PCM)- criteria

	DART	TANROADS	Government	CBO	NEMC
DART	1.00	1.00	1.00	2.00	5.00
TANROADS	1.00	1.00	1.00	3.00	4.00
Government	1.00	1.00	1.00	3.00	5.00
CBO	0.50	0.33	0.33	1.00	3.00
NEMC	0.20	0.25	0.20	0.33	1.00
Sum of column	*3.70*	*3.58*	*3.53*	*9.33*	*18.00*

Normalized PCM

	DART	TANROADS	Government	CBO	NEMC	score	RANK
DART	0.27	0.28	0.28	0.21	0.28	*0.26*	3
TANROADS	0.27	0.28	0.28	0.32	0.22	*0.28*	2
Government	0.27	0.28	0.28	0.32	0.28	*0.29*	1
CBO	0.14	0.09	0.09	0.11	0.17	*0.12*	4
NEMC	0.05	0.07	0.06	0.04	0.06	*0.05*	5
						1.00	

Ymax 5.07 CI 0.02 CR 0.02

PAIRWISE COMPARISON MATRIX (PCM)- sub criteria

	Bustop	PriRd	SecRd	TertRd
Bustop	1.00	1.00	2.00	6.00
PriRd	1.00	1.00	3.00	7.00
SecRd	0.50	0.33	1.00	5.00
TertRd	0.17	0.14	0.20	1.00
Sum of column	2.67	2.48	6.20	19.00

NMLZ PCM

	Bustop	PriRd	SecRd	TertRd	score	RANK
Bustop	0.38	0.40	0.32	0.32	*0.35*	2
PriRd	0.38	0.40	0.48	0.37	*0.41*	1
SecRd	0.19	0.13	0.16	0.26	*0.19*	3
TertRd	0.06	0.06	0.03	0.05	*0.05*	4
					1.00	

Ymax 4.09 CI 0.03 CR 0.03

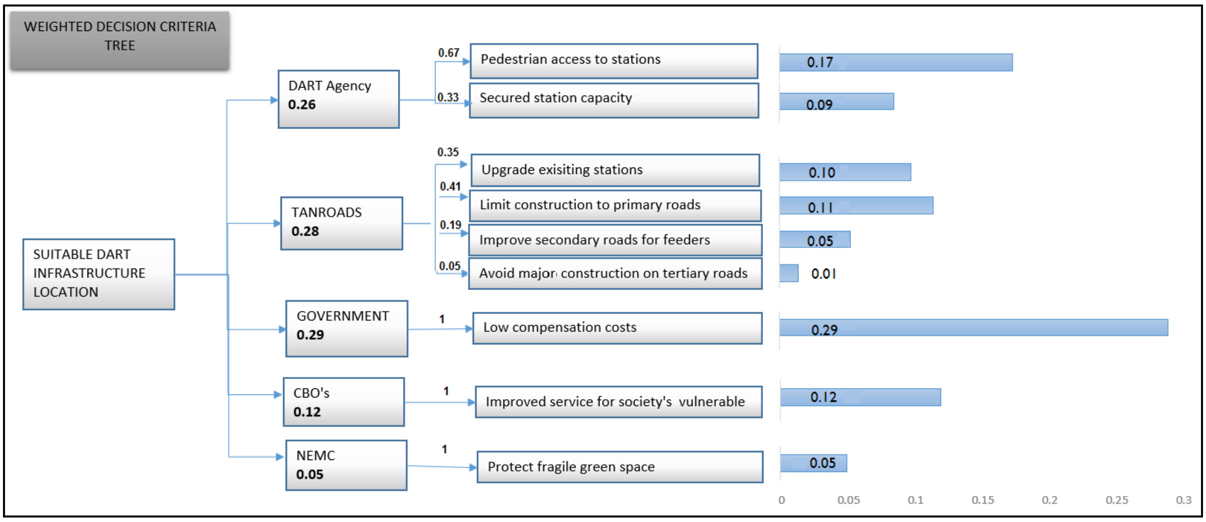


Figure 59 Pairwise comparison matrix for developing weighted decision criteria tree for station suitability for initial deliberation

8.2.3.1. DART Institutional goals

DART agency indicators for pedestrian access used foot paths selected within a 500 meter buffer zones of the DART corridors (Figure 60). DART planning documents stating that was the maximum distance they expect transit user to walk to access a station. From database paths stored as vector lines were retrieved and using ArcGIS, line density tool used to create a raster file for reclassification, set at natural break. High density values assumed to be dense network of footpaths and assigned suitable score. Indicator assumption was that the foot paths had limited obstructions and access to stations increase the chances of utilising them.

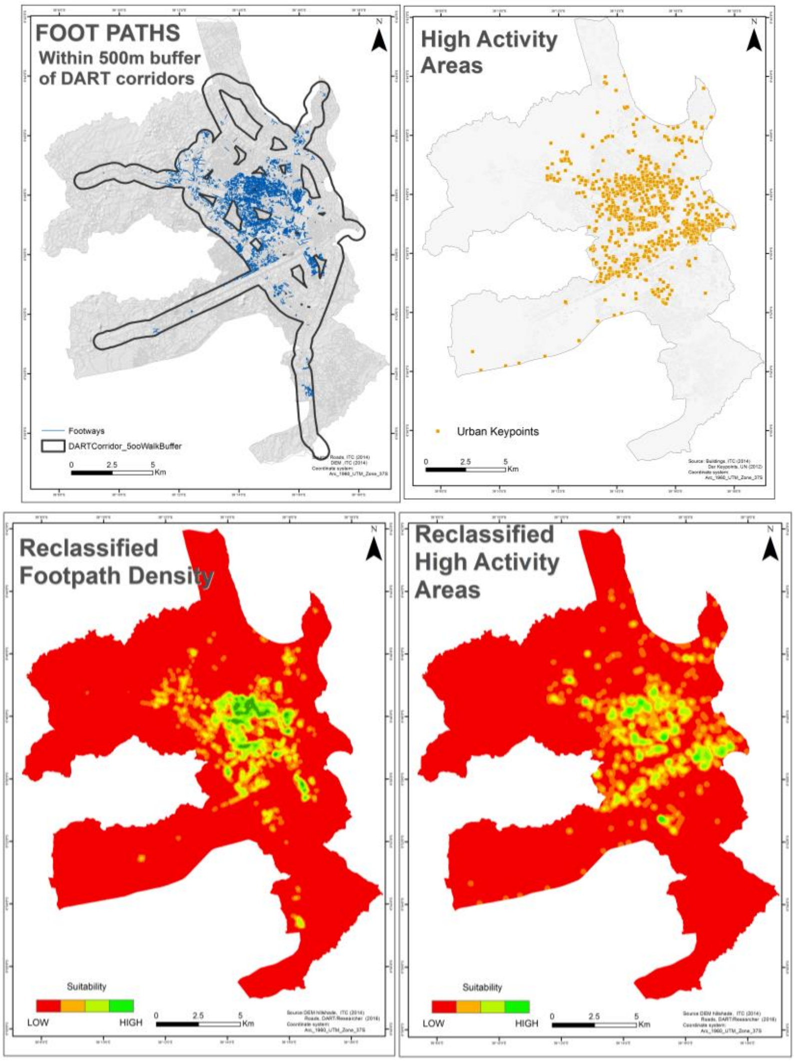


Figure 60 Suitability vector criteria and reclassified institutional factor maps
Source: Researcher 2016

Station capacity explicitly made use of urban activities available in an area. This was obtained from key point features of DSM and included shopping centres, banks, open markets, government institutions, community town halls and hospitals (Figure 60). This information can be provided by DSM transport consultants and transport regulation authority like SUMATRA who are most likely to have public transport OD related information. Kernel density of the points was generated to identify areas of high activity functions. The higher the density value the better the score. Assumption being these compact activity zones cannot be easily relocated as such demand is maintained for the stations.

8.2.3.2. TANROADS goals

The road infrastructure vector file was converted to raster using the polyline to raster conversion tool with classification of roads based on the categories as defined by DSM road management regulations of 2009 that describes road widths and reserves with primary roads of 60m width, highly suitable. Due to limited space in DSM and poor planning, optimal station space for DART is assumed to be in areas with primary road connections that tend to link zones of high activities. Land use data was reclassified with transportation and commercial zones assigned high suitability scores (Figure 61).

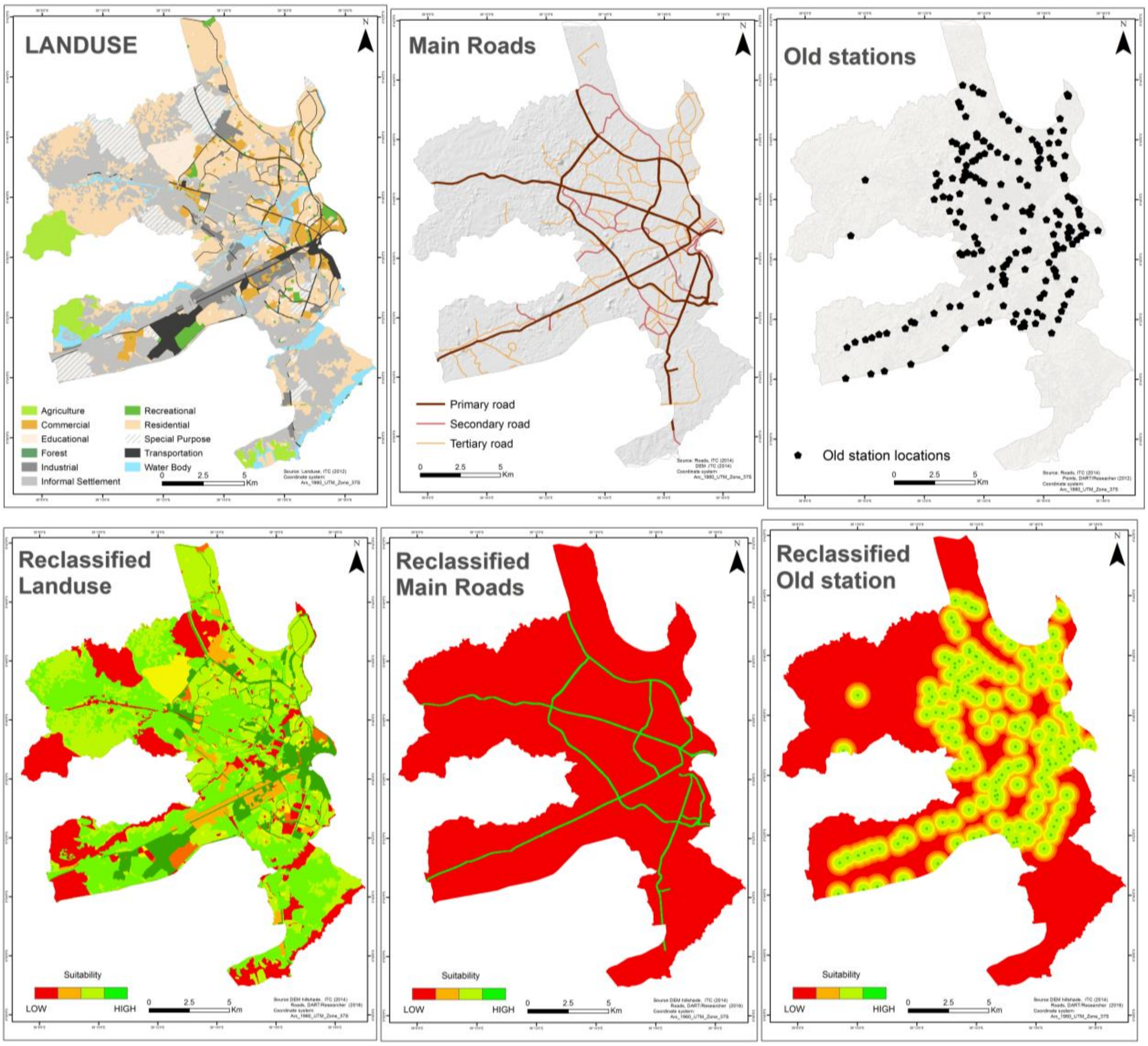


Figure 61 Suitability vector criteria and reclassified technical factor maps
Source: Researcher, 2016

Indicators for upgrade of old bus stations used Euclidean distances for the point features that were reclassified with 500 m buffer set at the neutral score. Considering pedestrian access coverage areas of the station. Below 50m was associated with a closer distance to the station and classified as highly suitable and 1000m and above highly unsuitable (Figure 61). Rationale for the indicator is that passenger demand is already available at existing stations in line with TANROADS preference of building up on existing infrastructures.

8.2.3.3. Government goals

Compensation matters utilised buildings vector data to operationalize under the assumption that the denser a zone is with residential buildings, the dense it is with utility provisions, the higher the chances for increased compensation and consequently less suitable from the economic perspective (Figure 62). Buildings structures being polygon features were converted to points before generating a kernel density raster file of 30x30m cell size to the extent of the AOI to obtain the buildings magnitude per unit. Reclassification was set at natural breaks with lowest range of buildings associated with less compensation hence more suitable and assigned the high score of 7.

8.2.3.4. Community goals

As a measure of community development, community goals was measured using population density. The assumption was that high density population areas are characterised by a higher number of the vulnerable low income population (Figure 62). Rationale for this was in relation DART development goal seeking to ease transit movement to opportunity activities especially for the deprived in society (DART, 2007). DSM ward administrative polygons features were populated with the 2012 DSM census population data. Wards with no data were assigned no data values and excluded from the analysis. Reclassification of raster data was based on calculated population density and scores were assigned using natural breaks. Areas of high population associated with more need for infrastructure provision for improved livelihood of the community.

8.2.3.5. Environmental Goals

NEMC in charge of compliance to environmental conditions was operationalized using river vector data. Euclidean distances were calculated and reclassified in relation to NEMC river buffer regulations of distances below 100 meters as highly unsuitable development zones (Figure 62). Distances away from the rivers are considered as suitable. Land use reclassification for recreation site, were assigned moderately unsuitable, agricultural, special sites, wetlands and forests grouped as highly unsuitable. Rationale is based on the lack of green spaces generally in DSM, that made any form development on the limited green spaces within the city highly unsuitable.

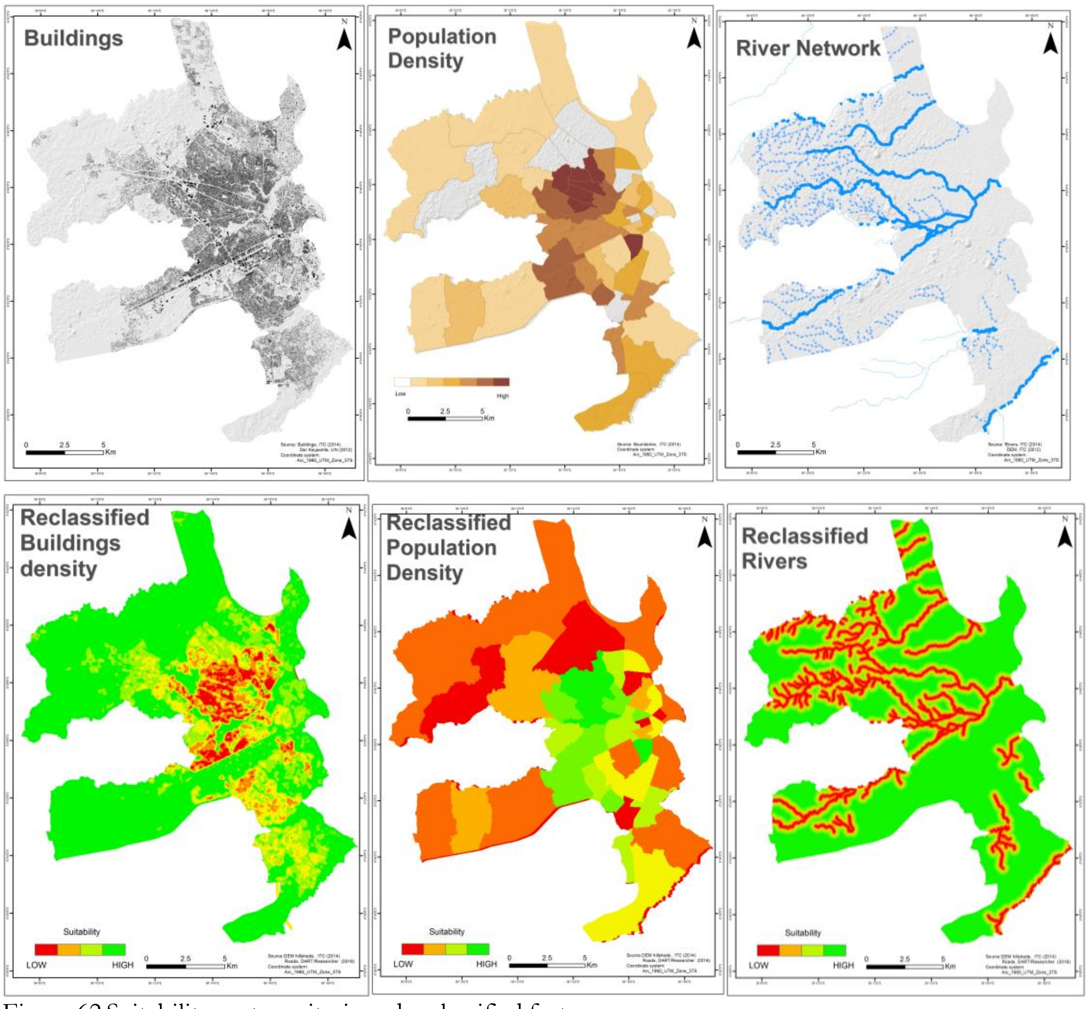


Figure 62 Suitability vector criteria and reclassified factor maps
Source: Researcher, 2016

8.2.4. Weighted Overlay Analysis and Identification of Suitable Station Sites

In a real stakeholder application setting this stage would involve GIS experts to apply weighted overlay analysis tool in ArcGIS as the stakeholders assigning and reassigning weights. Under facilitation by the consultant each stakeholder group's objective are given the equal opportunity to be the ideal lead objective from which other objectives are compared. These are termed as stakeholder visions. These visions are evaluated as standalone outcomes (Figure 65) before a composite map of all visions (Figure 66). The composite map illustrating areas the stakeholders could have less resistance to the location of a station and most suitable

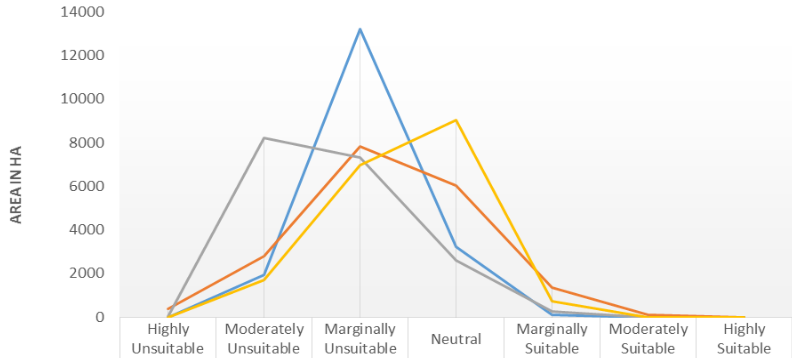
In the case of DART there were four considerations. Current decision group setting decisions termed business as usual vision, environmental vision, social vision and equal vision (Figure 65) with the areas classified using natural classifiers on a scale of 7 points ranging from highly unsuitable to highly suitable. Readjustments of the ranking were subjectively applied. This requires real deliberation to define the visions more clearly (Figure 63).

	INSIITUTIONAL DART AGENCY	**TECHNICAL** TANROADS	**ECONOMIC** GOVERNMENT	**SOCIAL** CBO	**ENVIRONMENTAL** NEMC
GROUP VISION	0.26	0.28	0.29	0.12	0.05
EQUALITY VISION	0.2	0.2	0.2	0.2	0.2
SOCIAL VISION	0.28	0.26	0.12	0.29	0.05
NATURE VISION	0.28	0.12	0.05	0.26	0.29

Figure 63 Readjustment weights for vision maps

Business as usual vision had matters of economic considerations associated with government objectives ranked marginally higher with a calculated weight of 0.29, followed by technical considerations by TANROADS at 0.28, institution matters of DART with 0.26, social issues ranked fourth with 0.12 and environmental objectives least with 0.05. Output of this vision produces areas that are marginally suitable to optimal station settings of approximately 86.67 hectares with most of DSM classified under unsuitable range (Figure 64). This results reflects the reality of DSM in which the unplanned development of the city has made it costly to restructure the area for sustainable development. Compensation matters limit any DART activity indeed within the current lanes. Since the corridors must also consider compensation of utility companies this is provided as a reason why the corridors do not illustrate much suitability from an economic view. This vision ranking last in relation to amount of suitable areas produced for DART infrastructure.

Environmental/Nature oriented vision produced the highest amount of area ranging in the suitable classifications with a total of 1424.7ha. Equality vision with equal weights of importance for all criteria manged to produce 741.78 ha of areas within suitability range. Social vision third with total area of 258.84ha. Of interest from the results observed was that none of the visions manage to produce an area highly suitable for the DART stations. This further reinforces the study's insight that spatial matters in DSM need to be clearly addressed to improve planning activities for the area.



	Highly Unsuitable	Moderately Unsuitable	Marginally Unsuitable	Neutral	Marginally Suitable	Moderately Suitable	Highly Suitable
ORIGINAL	0	1924.74	13221.54	3231	86.67	0	0
NATURE	375.03	2808.09	7840.89	6015.24	1336.32	88.38	0
SOCIAL	40.68	8216.46	7337.88	2610.09	258.57	0.27	0
EQUAL	0	1716.12	6986.07	9019.98	739.8	1.98	0

VISION SUITABILITY VALUES

Figure 64 Suitability areas in hectares for each vison

While the numbers help to know the amount of area made available or not, maps help to identify these areas in space for better build up and understanding of the information obtained. Maps are key interface tools in this design. Basic cartographic colour schemes to convey levels of suitability in a manner that makes it easy and direct for decision making need to be used. For this study orange to red gravitate towards unsuitable zones, light to dark green for suitable zones and yellow as neutral zones (Figure 65).

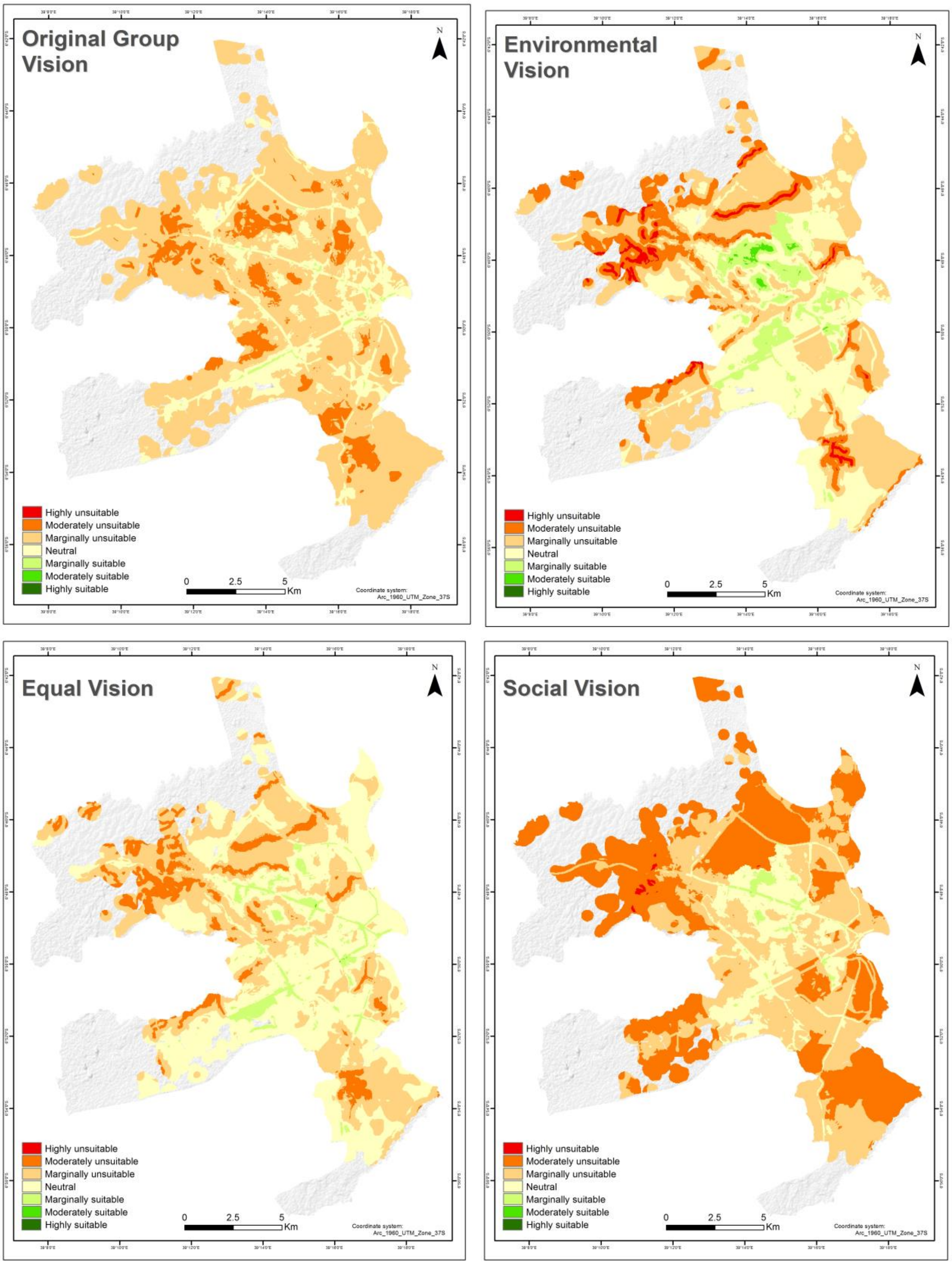


Figure 65 Stakeholder suitability vision maps
Source: Field research 2016

From visual interpretation, much of DSM is orange confirming the lack of suitable land for development. Suitable areas from the environmental vision are centred on areas with low income population. By using both maps and charts, information about the suitable areas allow for better deliberations.

As a final step, the individual vision maps are combined to develop a multi actor view using raster calculator in ArcGIS. This technique produces suitable sites from all visions. With the category of suitable areas sensitive in the case of DSM this study in the raster calculation for the suitability map considered sites that were either marginally or moderately suitable. Multi-actor vison for DART station location illustrate suitability areas along the Morgoro and Nyerere road (Figure 66).

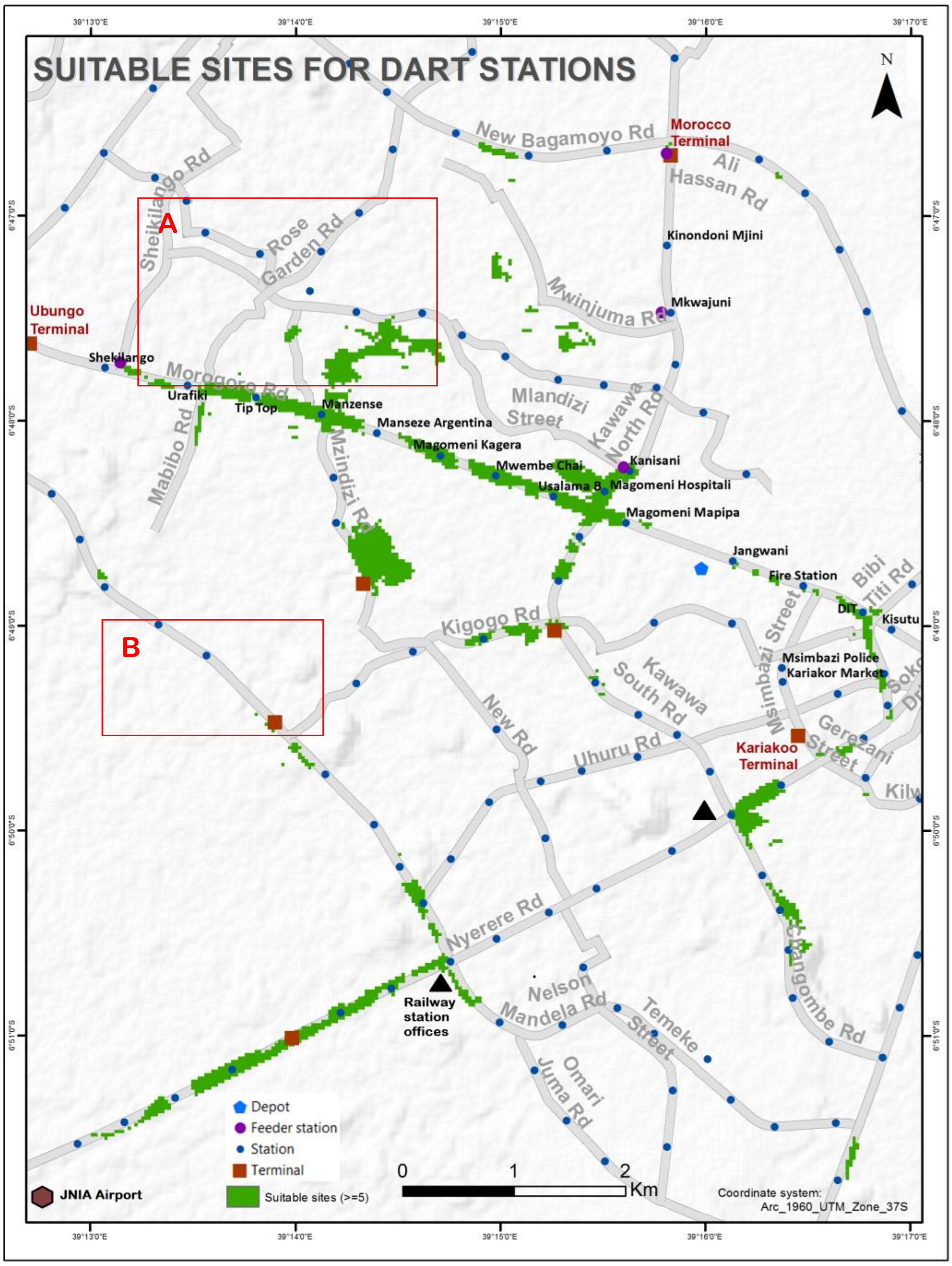


Figure 66 Suitable sites for station locations map for deliberations

Source: Researcher, 2016

Existing data can be overlaid and review of executed or planned activities deliberated further. This approach is useful in review meetings. In the case of Manzese stations (Figure 67) located in a suitable site, access to the stations are obstructed by roadside vendors who have extended market space from within the designated zone onto the BRT pathways. Such information leads to the identification of relevant stakeholders that could be incorporated into the deliberations of improved planning outcomes.

In some areas like Manseze Argentina, full BRT station in a non-suitable site has an empty station with accessibility lanes used as parking spaces (Figure 68). The GIS map interface supported by data collected like pictures improves communication setting for deliberations.

Figure 67 Reviews over decision outcomes along Morogoro Road
Source: Researcher 2016

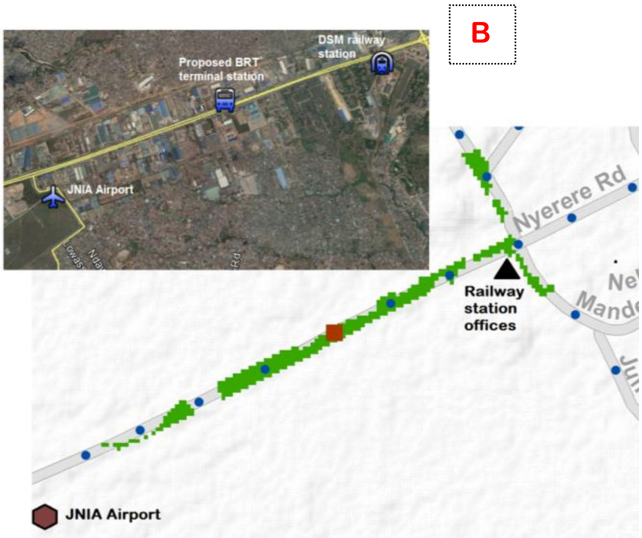


Figure 68 Improved deliberation of potential BRT station sites along Nyerere Road
Source: Researcher, 2016

For station sites that are potential, in this case along Nyerere road, deliberations into what makes them good site for a proposed transfer points can be identified. Clearly depicted for stakeholders, the location of rail and airport services at both ends can shape plans for integrated transport systems functioning as a unit for increased coverage for passengers. In relation to Nyerere much more industrial companies will be affected as such they need to be approached for improved planning decision making for the future infrastructure planning tasks.

8.3. Reflection on Applicability of the BRT-MCSDSS framework

The BRT MSCDSS design by constituting of common elements in SDSS design structures, manages to illustrate its applicability for a lead agency that is new to BRT tasks. It shows how spatial and supporting information can be presented and utilized to manage decision making practises with stakeholders.

For the planning case of DART, the design makes a contribution in stimulating current practises in station site location. If well facilitated the AHP tool using simple excel spread sheets and basic GIS tools and procedures can be a powerful communication tool. Since they are already existing tools in BRT planning, they enable the design to build the agency's in house technical capacity. The framework also allows for transparency, accountability and a systematic approach to site planning tasks. This however depends on the agency willingness to utilize the framework more in the planning tasks. With the project done in phases, the planning process would offer the BRT-MCSDSS design an opportunity to improve and develop its techniques, data collected and further research into improving decision making for BRT infrastructure site location plans.

The design's initial stage of task and stakeholder analysis tries to understand stakeholder needs and information concerns that shape their decision making practise. By focusing on the stakeholders and how they can achieve the task's objective, the data is more specialized saving time in reprocessing of general data. This allows relatively rapid retrieval, analysis and management of the GIS database stores. The design can increase the efficiency of information processing and the effectiveness of information made available to stakeholders for decision making.

The design output making use of maps, charts and photographs makes it an easy design to operate for planners familiar with GIS. But ethical matters may arise from the information of areas presented as less suitable areas in need of transport related infrastructure which might not be the case. The study acknowledges indeed up to date and well-coordinated spatial and non-spatial data for DSM was limited. This played a role in the presentation of some results with caution. Vector data utilized of a land use map for a city where development has occurred with no proper planning guide serves as an example.

With the project of DART being implemented in phases, the design has the opportunity to develop with the project and adapt. As well as improve stakeholders ease in using the tool for planning. This in turn offers a good research opportunity into understanding real actors' interaction with the tool and evaluate the outputs. This however would require the willingness of the agency and stakeholders who are to participate and utilize the tool in the planning process.

Lack of actual application of the design limits the discussion of the study on how stakeholders participate in the decision making process. Documents can assist in identifying stakeholders and provide information of the general view of conflict or consensus between stakeholders. However it falls short in describing how the decision processes would have taken place. Stakeholder objectives are not static and getting to know how the design could adjust to changes in stakeholder information needs for decision making would have been an advantage to the design.

Despite this, the design illustrates information that can be supported by documents and actual field visit. This aspect improves its validity as a possible application framework for the case of DART in addressing decision problems of site location its station infrastructure.

9. CONCLUSIONS AND RECOMMENDATIONS

This research was conducted with an overall objective of examining the BRT planning processes to understand stakeholder participation in decision making so as to conceptually design a collaborative SDSS application framework for BRT infrastructure. This chapter hence presents the concluding remarks for the study in relation to the study objective and recommendations for further studies included at the end.

9.1. Conclusions

The first sub-objective of the study was to understand the BRT infrastructure planning process. This had three guiding questions:" What are the infrastructure planning tasks in the BRT planning process?" Second question, "What roles/responsibilities do stakeholders have in the planning tasks?" Final question, "How do stakeholders collaborate in the decision making process for infrastructure planning?"

In depth review of literature enabled the identification of the institutional BRT planning models from the Institute for Transport and Development Policy (ITDP) which the study reviewed as well as the German Technical Cooperation (GTZ) and Transportation Research Board TRB models. For each model, the planning tasks were different due to differences in model structures and principles. While ITDP and GTZ models were relatively business oriented with the planning process having tasks in phases that related to planning for the BRT components, TRB structure was composed of the BRT elements themselves which the model focused on. However the models indicated that the common and key planning tasks of BRT planning for infrastructure to be the preparation for BRT project, identification of stakeholders, designing of the BRT elements and planning for the integration of the system. Main infrastructure to be provided should be a network of reasonable corridor extent with stations that facilitate ease in transfer in-between transport networks.

Preparing for BRT project as the initial task involved the setting up of the projects team that was to facilitate the planning of the BRT system and define the objective of the tasks in the planning process. Stakeholder analysis in the planning process was done to secure support for the project by building communication strategies that could facilitate participation of stakeholders. Demand analysis concluded to be of key importance in BRT planning for infrastructure, provided the information on which major decisions for the infrastructure were to be based on. The information from this task structured the decisions for the design task, both operational and physical which were considered to be the core of the planning process since the design defined the optimal structure of the BRT being developed. Task of system integration in turn was dependent on the design and it was to check that the BRT was in sync within its own system as well as existing city systems.

The roles and responsibilities of the stakeholders in the planning tasks varied depending on the skills, information, interests, concerns or problems that the stakeholder had in and from the execution of a planning activity. In the stakeholder analysis, stakeholders were sources of information on who to involve and how, for the project to have minimum resistance in the planning process. Demand analysis had stakeholders as either participants (public transport user, transport providers), facilitators (modelling consultants) or mediators (traffic enforcers, transport agencies). The main role for all being the building of the demand information for the BRT project. In the design task stakeholders were sources of information, participants in making decisions, facilitators or mediators same with the task of system integration.

How stakeholders collaborated in the decision making process for BRT planning was not clearly defined in the models but elements of it having occurred could be inferred. The process itself can be concluded as being limited to top level project stakeholders with top down approach to decision making being a barrier to collaborative planning with stakeholders. Despite this, deliberation sessions take place in meetings that can be open public meetings where the public voice their opinions on the BRT project. Specialized stakeholder deliberation that targets specific groups or the more common meetings for high level deliberations among experts. Tools used to facilitate stakeholder participation include computer modelling software tools with community collected data, GIS tools, local judgement for multi-criteria evaluations and community mapping using GPS.

In the case of the BRT planning process in Dar es Salaam that asked the same questions as the first sub objective, the planning phases were project design, implementation and operations. The planning structure is anchored on demand studies guiding the design of operations, infrastructure and business plan for which a bidding process for operations can be facilitated (see 7.2). Despite the difference in model structure the planning process illustrated similar concept of project preparation, stakeholder analysis, demand analysis that was its base design and system integration.

The design phase of DART project had all the activities relating to this study. Stakeholder analysis was incorporated in the project's environmental and social impacts assessment, ESIA, which was to include the framework for relocating project affected people, PAPs. This required the identification of the stakeholders, gathering and disseminating of project information. Demand analysis as a key task in the planning process, design and system integration made use of the collaborative efforts of local and international design experts using modelling tools. The outputs were objective information to guide decision making for the planning process. However political influences present barriers that require skilled planners to manage by establishing the use of tools that advocate for a transparent processes in decision making.

The roles and responsibilities of the stakeholders in the planning tasks varied depending on the group category of the stakeholders. Key stakeholders, with expertise and power for the project, mainly government offices, DART agency TANROADS Interconsult/Logit were tasked with activities leading to project implementation. Primary stakeholder being affected positively or negatively were sources of information that included providing of mitigation strategies. Intermediaries had the role of influencing decisions made and hence were more mediators needed to bridge the primary and key stakeholders. Main mediator sin DART being the local "Mtaa" leaders who offered a link to grassroots level support for the project.

Collaborative decision making in DART project was limited to key stakeholder levels. The process ranged from decisions being made on a DART agency planning unit level onto the deliberation of the project by board and committee members. Detailed information about this process however was limited and presented a challenge for this study in designing the application of the SDSS as the final objective.

To design a collaborative SDSS framework for DART, three questions were asked. First, "What are the spatial decision problems in BRT planning?" Second, "What elements could make up a BRT SDSS?" and finally "How would a group-SDSS for DART be structured?"

Spatial decision problems vary depending on the specific city set up and the infrastructure planning activity. In corridor selection, spatial problems arise from the type of BRT solution that could be preferred among stakeholders. This ranges from having part time road lanes without segregation to fully-segregate median trunk and feeder lanes. Network coverage decision problems involve options of locating pilot project or full systems which are weigh against factors of social considerations or system ridership for effectiveness. Network design decision problems relate to corridor space, transfer point location to utility line relocation. Transfer point location having most of the decision problems. These tend to be more complicated in areas of limited urban space that could lead to potential invasion of vulnerable sites as was the case of DART Jangwani depot (see Figure 54). System integration decision problems relate to weighing alternatives of TOD, and park and ride facilities.

Since the BRT planning process varies with city contexts and tasks, a flexible group SDSS structure that can adapt to different planning scenarios is a principle element. And considering the top down approach to decision making in BRT infrastructure planning, transparency and systematic procedures in decision making are key elements a supporting tool should provide. Based on these two notions the study concludes that multi-criteria spatial decision support system (MC-SDSS) are ideal for a BRT SDSS tool. The AHP component of the MCDA provides easy to understand computations. It shows a systematic procedure of how a decision was reached and requires no special skill from participants. In addition, its available as a software package, but for offices with limited resources readily available spreadsheet software can be applied. GIS enables stakeholders to visualize their decision choices on virtual space before further actions are done that could negatively impact the project.

For the case of DART, the study is for the opinion that its lack of spatial guiding resources, specifically the lack of an updated development plan, creates a need for a BRT-MCSDSS. The tool should be structured to support the task of identifying locations suitable (as illustrated in section 8.1) for BRT infrastructure. Key procedures include iterative process of consultants and researcher conducting stakeholder and task analysis to identify and group stakeholders with similar objectives in the planning of a particular infrastructure. DART agency organize the deliberation meeting for which the identified stakeholder are invited to participate. Deliberation sessions is facilitated by the consultant while researchers observe and record the activities done in the decision making process. This includes information on agreement or trade off thresholds, conflict resolution mechanisms and information needs among stakeholders. GIS experts and researchers identify the criteria indicators using regulations, standards and stakeholder information that are presented to stakeholder participants for confirmations. GIS experts incorporate the weights with spatial data representing the stakeholder's decision impacts in space. This information is then deliberated by the group.

While the tool is seen as beneficial to DART planning, it acknowledges institutional barriers that limit the application. Use of the tool and application of the results in real case depends on user willingness. This included the agency, decision makers and other stakeholders. In addition, data to be used need to accurate and readily available. This might require additional resources that might not be available

9.2. Recommendation

Based on the review of BRT planning process for developing cities, recommendations advocated for include:

- Investigations into how a hybrid BRT model for a city case like Dar es Salaam should be structured. Since the roads are classified by administrative levels the TRB model is suitable but having paratransit system makes the ITDP model suitable as well. Each model has it strengths that are important and the potentials of either of the two should not be overlooked

- In compiling of institutional reports in the DART planning process collaborative reporting should be advocated for in current phase developments. This builds information on the decision making process for both technical and social dimensions improving the learning process on how deliberation sessions happen. And as the project moves on to subsequent phases, better tools can be applied to see how they contribute to the process and need to be structured.

- Study considerations on BRT should highlight the involvement of other stakeholders. By limiting stakeholder information on bus operators and concession companies being formed, little then is known about the extent of which other stakeholders need to be involved in the BRT planning process. Addressing this helps in understanding the BRT collaborative process requirements. The focus on specifically bus operators presents a gap for DART's transport planning. DART should engage more with the other paratransit stakeholders as its public transport systems despite the similarities with TransMilenio is unique. Research should look into stakeholder mechanisms that can manage the challenging task of involving paratransit stakeholders. Use of the internet and polling systems in transport planning could potentially offer a solution.

- Technical recommendation is the practical application of the BRT MCSDSS tool in site location for a city with dire spatial problems. Real case application with planners and stakeholders would improve this study and enable the assessment of stakeholder participation in the decision making process more coherent for more stable analysis. This would identify ways the application and structure could be improved.

- Additionally, in developing institutions like DART, partnering with research institutions on a more practical level of planning would advocate for more in house capacity building. From a short term perspective, partnering with planning institutions would help assess real case applicability of the tool. From a long term perspective the tool could be anchor in real case applicability. This perspective assumes that the BRT development plans will be implemented. Since this will be done in phases with different stakeholder settings, the process of decision making with stakeholders can be better evaluated for improvements of the tools structure and testing within the institution of an emerging BRT system in a city.

LIST OF REFERENCES

Agyemang, E. (2015). The bus rapid transit system in the Greater Accra Metropolitan Area , Ghana : Looking back to look forward. *Norwegian Journal of Geography*, *69*(February), 28–41. http://doi.org/10.1080/00291951.2014.992808

Ardila-Gomez, A. (2004). *Transit Planning in Curitiba and Bogotá. Roles in Interaction, Risk, and Change*. Massachusetts Institute of Technology. Retrieved from https://dspace.mit.edu/handle/1721.1/28791

Ardila, A. (2002). A tale of two plans: Determinants of plan implementation. *Transportation Research Record*, *1817*(June), 149–154. http://doi.org/10.3141/1817-19

Arnstein, S. R. (1969). A ladder of citizen participation. *Journal of the American Institute of Planners*, *35*(4), 216–224. http://doi.org/10.1080/01944366908977225

Auwerx, P., Bossaert, E., Martens, S., Cuixart, J., & Forjan, S. (2011). *Involving stakeholders: Toolkit on organising successful consultations*. Retrieved from http://www.civitas.eu/sites/default/files/Results and Publications/Brochure_STAKEHOLDER_CONSULTATION_web.pdf

Bal, M., Bryde, D., Fearon, D., & Ochieng, E. (2013). Stakeholder Engagement: Achieving Sustainability in the Construction Sector. *Sustainability (Switzerland)*, *5*(2), 695–710. http://doi.org/10.3390/su5020695

Cain, A., Darido, G., Baltes, M. R., Rodriguez, P., & Barrios, J. C. (2006). *Applicability of Bogotá ' s TransMilenio BRT System to the United States. FL-26-7104-01.*

Carrigan, A., King, R., Velasquez, J. M., Raifman, M., & Duduta, N. (2013). *Social, Environmental, and Economic Impacts of Bus Rapid Transit: Case Studies from Around the World*. *Embarq*.

Cascetta, E., Carteni, A., Pagliara, F., & Montanino, M. (2015). A new look at planning and designing transportation systems: A decision-making model based on cognitive rationality, stakeholder engagement and quantitative methods. *Transport Policy*, *38*, 27–39. http://doi.org/10.1016/j.tranpol.2014.11.005

Cervero, R. (2000). Informal Transport In the Developing World. *UN Habitat*, 117–144. Retrieved from http://mirror.unhabitat.org/pmss/getElectronicVersion.aspx?nr=1534&alt=1

Chandio, I. A., Iacsit, M., Nasir, A., & Matori, B. (2011). GIS-based Multi-criteria Decision Analysis of Land Suitability for Hillside Development. *International Journal*, *2*(6), 2–6.

Chen, Y., Yu, J., & Khan, S. (2013). The spatial framework for weight sensitivity analysis in AHP-based multi-criteria decision making. *Environmental Modelling and Software*, *48*, 129–140. http://doi.org/10.1016/j.envsoft.2013.06.010

Coutinho-Rodrigues, J., Simão, A., & Antunes, C. H. (2011). A GIS-based multicriteria spatial decision support system for planning urban infrastructures. *Decision Support Systems*, *51*(3), 720–726. http://doi.org/10.1016/j.dss.2011.02.010

DART. (2007a). *Conceptual design of a long term integrated Dar es Salaam BRT system and detailed design for the initial corridor* (Vol. 5). Dar es Salaam.

DART. (2007b). *Environmental and Social Imapct Assessment (ESIA) study* (Vol. 3). Dar es Salaam.

DART. (2009). DART executive report [Powerpoint Slides]. Dar es Salaam.

DART. (2014a). *Dar Rapid Transit (DART) Project Phase 1: Project Information Memorandum*. Dar es Salaam. Retrieved from http://dart.go.tz/sw/wp-content/uploads/2015/01/DART-Project-Information-Memorandum.pdf

DART. (2014b). *DART project information: Appraisal document*. Dar es Salaam. Retrieved from http://documents.worldbank.org/curated/en/976241468312624211/pdf/PID-Appraisal-Print-P123134-12-12-2014-1418408517694.pdf

Echeverry, J. C., Ibáñez, A. M., Moya, A., & Hillón, L. C. (2005). The economics of TransMilenio, a mass transit system for Bogotá. *Economia*, *7191*, 151–195. http://doi.org/10.1353/eco.2005.0014

El-Gohary, N. M., Osman, H., & El-Diraby, T. E. (2006). Stakeholder management for public private partnerships. *International Journal of Project Management*, *24*(7), 595–604. http://doi.org/10.1016/j.ijproman.2006.07.009

Ferro, P. S., & Behrens, R. (2015). From direct to trunk-and-feeder public transport services in the Urban South: Territorial implications. *Journal of Transport and Land Use*, *8*(1), pp 123-136.

http://doi.org/10.5198/jtlu.2015.389
Friese, S. (2014). *Qualitative data analysis with ATLAS.ti.* London, England: Sage Publications. http://doi.org/10.1080/1369118X.2013.870379
Gale, N. K., Heath, G., Cameron, E., Rashid, S., & Redwood, S. (2013). Using the framework method for the analysis of qualitative data in multi-disciplinary health research. *BMC Medical Research Methodology*, *13*(1), 117. http://doi.org/10.1186/1471-2288-13-117
GoT. (2016). *Comprehensive review report for Tanzania: Five year development plan 2011/2012-2015/16.* Dar es Salaam.
Gwilliam, K. (2002). *Cities on the move:A World Bank urban transport strategy review. A World Bank Publication.* Washington DC.
Hidalgo, D. (2002). TransMilenio: A high capacity–low cost bus rapid transit system developed for Bogotá, Colombia. In *Proceedings of the Second International Conference, April 14-18, 2002, Alexandria, Virginia, USA*. Retrieved from http://www.codatu.org/wp-content/uploads/Transmilenio-A-high-capacity-low-cost-bus-rapid-transit-system-developed-for-Bogota-Colombia-D.-HIDALGO.pdf
Hidalgo, D. (2005). *TransMilenio's contributions to the development of Bus Rapid Transit Systems.* Retrieved from http://www.bogotalab.com/articles/transmilenio.html
Hidalgo, D., & Graftieaux, P. (2010). A Critical Look at Major Bus Improvements in Latin America and Asia: Case Study TransMilenio, Bogotá, Colombia, 1–41.
Hidalgo, D., & Gutiérrez, L. (2013). BRT and BHLS around the world: Explosive growth, large positive impacts and many issues outstanding. *Research in Transportation Economics*, *39*(1), 8–13. http://doi.org/10.1016/j.retrec.2012.05.018
Hidalgo, D., & Zeng, H. (2013). On the move: Pushing sustainable transport from concept to tipping point. Retrieved September 12, 2016, from http://thecityfix.com/blog/on-the-move-pushing-sustainable-transport-concept-tipping-point-dario-hidalgo-heshuang-zeng/
ITDP. (2007a). *Bus Rapid Transit Planning Guide.* (L. Wright, Ed.)*Institute for Transportation & Development Policy* (3rd ed.). New York: ITDP. http://doi.org/2007
ITDP. (2007b). Project preparation. In *Bus Rapid Transit: Planning guide* (pp. 32–211).
ITDP. (2016). Where We Work. Retrieved September 9, 2016, from https://www.itdp.org/where-we-work/
Jain, L. C., & Lim, C. P. (2010). *Handbook on Decision Making: Vol 1: Techniques and Applications. Intelligent Systems Reference Library* (Vol. 4). http://doi.org/10.1007/978-3-642-13639-9
Jankowski, P. (2007). Integrating geographical information systems and multiple criteria decision-making methods. *International Journal of Geographical Information Systems*, *9*(3), 252–273. http://doi.org/10.1080/02693799508902036
Jankowski, P., Robischon, S., Tuthill, D., Nyerges, T., & Ramsey, K. (2006). Design considerations and evaluation of a collaborative, spatio-temporal decision support system. *Transactions in GIS*, *10*(3), 335–354. http://doi.org/10.1111/j.1467-9671.2006.01001.x
JICA. (2008). *Dar es Salaam transport policy and system development master plan report*. Dar es Salaam.
Johannessen, G. H. J., & Hornbæk, K. (2014). Must evaluation methods be about usability? Devising and assessing the utility inspection method. *Behaviour & Information Technology*, *33*(2), 195–206. http://doi.org/10.1080/0144929X.2012.751708
Ka'bange, A., Mfinanga, D., & Hema, E. (2014). Paradoxes of establishing mass rapid transit systems in african cities - A case of Dar es Salaam Rapid Transit (DART) system, Tanzania. *Research in Transportation Economics*, *48*, 176–183. http://doi.org/10.1016/j.retrec.2014.09.040
Kok, J. L., Kofalk, S., Berlekamp, J., Hahn, B., & Wind, H. (2009). From design to application of a decision-support system for integrated river-basin management. *Water Resources Management*, *23*(9), 1781–1811. http://doi.org/10.1007/s11269-008-9352-7
Kombe, W., Kyessi, A., Lupala, J., & Mgonja, E. (2003). *Partnerships to improve access and quality of public transport: A case report of Dar es Salaam, Tanzania. Loughborough University.* Retrieved from https://dspace.lboro.ac.uk/2134/9566
Kumar, A., Zimmerman, S., & Agarwal, O. P. (2012). The soft side of BRT: Lessons from five developing cities. *The International Bank for Reconstruction and Development/The World Bank Group.*
Lámbarry, F., Trujillo, M. M., & Rivas, L. A. (2013). Planning Models for a Bus Rapid Transit System (BRT): The Case of Metrobus in Mexico City. *International Journal of Business and Management*, *8*(15), 130–143. http://doi.org/10.5539/ijbm.v8n15p130

Levinson, H., Zimmerman, S., Clinger, J., Rutherford, S., Smith, R. L., Cracknell, J., & Soberman, R. (2003). Bus Rapid Transit. *Transit Cooperative Research Program Report 90 Bus Rapid Tranist*, *Volume 1:*
Lewis, J. K. (2016). Using ATLAS . ti to Facilitate Data Analysis for a Systematic Review of Leadership Competencies in the Completion of a Doctoral Dissertation, 1–14. http://doi.org/10.14279/depositonce-5156
Li, N., Zou, X., & Levinson, D. M. (2004). The Integrated Use of EMME / 2 and Arc / Info. *45th Transportation Research Forum Annual Meeting*, 1–12. Retrieved from https://ssrn.com/abstract=1748572
Lillo, E., Wensell, U., & Willumsen, L. (2003). Bus Transit Systems : the case of Transmilenio. In *International Conference: Contemporary Tramway and LRT Systems*. Patras: Steer davies gleav. Retrieved from www.steerdaviesgleave.com
Lindau, L. A., Hidalgo, D., & de Almeida Lobo, A. (2014). Barriers to planning and implementing Bus Rapid Transit systems. *Research in Transportation Economics*, *48*, 9–15. http://doi.org/10.1016/j.retrec.2014.09.026
MacHaris, C., Turcksin, L., & Lebeau, K. (2012). Multi actor multi criteria analysis (MAMCA) as a tool to support sustainable decisions: State of use. *Decision Support Systems*, *54*(1), 610–620. http://doi.org/10.1016/j.dss.2012.08.008
Mlambo, A. (n.d.). High capacity public transport in East Africa: The Dar rapid transit (DART) [Powerpoint Slides]. Retrieved from http://mirror.unhabitat.org/downloads/docs/7997_11369_ASTERIA.pdf
Mobereola, D. (2009). *Africa's First Bus Rapid Transit Scheme: The Lagos BRT-LiteSystem. The International Bank for Reconstruction and Development/The World Bank*. Washignton D.C.
Moller, R. (2010). A critical evaluation of the Colombian model of mass or bus rapid transit systems. *Ingeniería Y Competitividad*, *12*(2), 23–40. Retrieved from http://bibliotecadigital.univalle.edu.co/handle/10893/3438
Mota, C. M. de M., de Almeida, A. T., & Alencar, L. H. (2009). A multiple criteria decision model for assigning priorities to activities in project management. *International Journal of Project Management*, *27*(2), 175–181. http://doi.org/10.1016/j.ijproman.2008.08.005
Mysiak, J., Giupponi, C., & Cogan, V. (2002). Challenges and Barriers To Environmental Decision Making : a Perspective From the Mulino Project. *Proceedings from the Eighth EC-GI & GIS Workshop, ESDI—A Work in Progress*, 1–13. Retrieved from https://pdfs.semanticscholar.org/7624/91341e980493fd5ddf3718ba1a688218da86.pdf
Mzee, P. K., & Demzee, E. (2012). ITS Applications in Developing Countries : A Case Study of Bus Rapid Transit and Mobility Management Strategies in Dar es Salaam – Tanzania. *Intelligent Transportation Systems*, (ISBN: 978-953-51-0347-9). Retrieved from http://www.intechopen.com/books/intelligent-transportation-systems/
NIUA. (2015). *Urban Transportation in Indian Cities: Compendium of Good Practices*. Retrieved from http://citynet-ap.org/wp-content/uploads/2015/05/GP-IN1-UT.pdf
OECD. (2015). *Stakeholder involvement in decision making: A short guide to issues, approaches and resources*. Retrieved from http://www.oecd-nea.org/rwm/pubs/2015/7189-stakeholder-involvement-2015.pdf
Olander, S., & Landin, A. (2005). Evaluation of stakeholder influence in the implementation of construction projects. *International Journal of Project Management*, *23*(4), 321–328. http://doi.org/10.1016/j.ijproman.2005.02.002
Pacho, T. (2015). Exploring participants' experiences using case study. *International Journal of Humanities and Social Science*, *5*(4), 44–53. Retrieved from http://www.ijhssnet.com/journals/Vol_5_No_4_April_2015/5.pdf
Pojani, D., & Stead, D. (2015). Sustainable Urban Transport in the Developing World: Beyond Megacities. *Sustainability*, *7*(6), 7784–7805. http://doi.org/10.3390/su7067784
Prouty, C., Koenig, E. S., Wells, E. C., Zarger, R. K., & Zhang, Q. (2016). Rapid assessment framework for modeling stakeholder involvement in infrastructure development. *Sustainable Cities and Society*, *29*, 130–138. http://doi.org/10.1016/j.scs.2016.12.009
Rizvi, A. (2014). *How Planing Process Impacts Bus Rapid Transit Outcomes: A Comparision of Experiences in Delhi and Ahmedabad, India*. Colombia University.
Ruiz, M. C., Romero, E., Pérez, M. A., & Fernández, I. (2012). Development and application of a multi-

criteria spatial decision support system for planning sustainable industrial areas in Northern Spain. *Automation in Construction*, *22*, 320–333. http://doi.org/10.1016/j.autcon.2011.09.009
Satiennam, T., & Fukuda, A. (2006). A study on the introduction of Bus Rapid. *International Association of Traffic and Safety Sciences*, *30*(2), 59–69. http://doi.org/10.1016/S0386-1112(14)60170-9
Schalekamp, H., & Behrens, R. (2013). Engaging the paratransit sector in Cape Town on public transport reform: Progress, process and risks. *Research in Transportation Economics*, *39*(1), 185–190. http://doi.org/10.1016/j.retrec.2012.06.012
Soltani, A., Hewage, K., Reza, B., & Sadiq, R. (2015). Multiple stakeholders in multi-criteria decision-making in the context of municipal solid waste management: A review. *Waste Management*, *35*, 318–328. http://doi.org/10.1016/j.wasman.2014.09.010
Soo, H., Teodorovic, D., & Collura, J. (2006). A DSS framework for advanced traffic signal control system investment planning. *Journal of Public Transportation*, *9*(4), 87–106. Retrieved from http://131.247.19.1/jpt/pdf/JPT 9-4 Soo.pdf
Sugumaran, R., & DeGroote, J. (2013). *Spatial decision support system. Spatial Decision Support Systems* (Vol. 53). CRC Press. http://doi.org/10.1017/CBO9781107415324.004
Tirachini, A. (2014). The economics and engineering of bus stops: Spacing, design and congestion. *Transportation Research Part A: Policy and Practice*, *59*, 37–57. http://doi.org/10.1016/j.tra.2013.10.010
TRB. (n.d.). Pittsburgh, Pennsylvania; South East and West busways. Retrieved from http://onlinepubs.trb.org/onlinepubs/tcrp/tcrp90v1_cs/Pittsburgh.pdf
TRB. (2003). *Transit Cooperative Research Program Report 90: BRT Implementation Guidelines* (Vol. 2). Washington DC. Retrieved from http://www.trb.org
UNDP. (2011). Successful Public-private Partnerships: Case Bus Rapid Transit Project, Bogota. *Sharing Innovative Experiences*, *15*, 83–92. Retrieved from http://academy.ssc.undp.org/GSSDAcademy/SIE/VOL15.aspx
Vilchis, F. L., Tovar, L. A. R., & Flores, M. M. T. (2012). Conflict Resolution through Consensus Building Approach in the Implementation of Bus Rapid Transit System. *International Journal of Business and Management*, *7*(14), 1–17. http://doi.org/10.5539/ijbm.v7nl4pl
Wright, L. (2003). *Bus Rapid Transit. Sustainable Transport: A Sourcebook for Policy-makers in Developing Cities*. Retrieved from http://discovery.ucl.ac.uk/112/1/BRT_e-book.pdf
Wu, I., & Pojani, D. (2016). Obstacles to the creation of successful bus rapid transit systems: The case of Bangkok. *Research in Transportation Economics*, 1–10. http://doi.org/10.1016/j.retrec.2016.05.001
Wu, W., Gan, A., Cevallos, F., & Shen, L. D. (2011). Selecting Bus Stops for Accessibility Improvements for Riders with Physical Disabilities. *Journal of Public Transportation*, *14*(2), 133–149.
Zak, J. (2010). Decision Support Systems in Transportation. In *Intelligent Systems Reference Library* (Vol. 4, pp. 249–294). http://doi.org/10.1007/978-3-642-13639-9

Annexes

Annex 1 Summary of BRT system and related decision activities and planning issues

BRT ELEMENTS & THEIR OPTIONS	SYSTEM PERFORMANCE					SYSTEM BENEFIT	PLANNING ISSUE
	Travel Time	Reliability	Identity and Image	Safety and Security	Capacity		
Running ways ▪ Mixed flow lanes with jump queue ▪ At-Grade exclusive lane (Transit way) ▪ Grade-Separated exclusive Lane	▪ Separation increase reduces congestion delays	▪ Reduces risk of delay due to non- recurring congestion and accidents with separation	▪ Segregation portrays permanent investment	▪ Separation reduced traffic hazard A	▪ Increase capacity from multiple lanes ▪ Separation reduces congestion delay increasing output	▪ Image of permanent investment attracts development ▪ Speed benefits enhance ridership and of environmental benefit	▪ Availability of right of way ▪ Enforcement for managing conflicts leading to delay and safety problems
Station Station Type ▪ Basic shelter ▪ Designated station ▪ Intermodal transit Center	▪ Minimal transfer times from integrated station		▪ Enhanced brand identity from more distinct station types ▪ Customer appeal from additional amenities	B	▪ Large stations increase capacity	▪ Defined stations attract potential development activities	▪ Zoning regulations on design ▪ Landscape integration of station
Station Access ▪ Pedestrian linkages ▪ Park and ride facility			▪ Attracts ridership from highlighting access provision	▪ Integration with community with better pedestrian linkages		▪ Improved access to attract customers	▪ Pedestrian access and safety in and around BRT stations ▪ Security at stations
Vehicle Configuration ▪ Conventional standard ▪ Conventional articulated ▪ Specialized BRT vehicle	▪ Reduce dwell time delays1 from low floors	▪ Reduced variation in dwell time from low	▪ Advances vehicles boost community linkages	▪ Minimal tripping hazard with low floor	▪ Large vehicles increase capacity	▪ Advanced vehicle attract ridership	▪ Maintenance and storage facilities for BRT vehicles
▪ Energy use system			▪ Low emissions systems enhance			▪ Maximized environmental quality from low	▪ Monitoring for pollution

			environmental image of BRT			emissions systems	
Intelligent Transport System ▪ Operations Management	▪ Active operations management ▪ maintains schedules, minimizing, wait time	▪ Active operations management focuses on maintaining		▪ Vehicle tracking systems enable monitoring of vehicles	▪ Operations management ensures that capacity matches demand	▪ Increased operating efficiencies	▪ BRT site to have wireless or wire line advanced communication systems ▪ Too much data to handle
▪ Support Technologies ▪ Archived data ▪ Passenger counter					Enabled operations to meet needed demand	▪ Provision of valuable planning information for planning BRT	
▪ **Service and operation** ▪ Route Length		▪ Shorter routes promote greater control of reliability					
Route structure ▪ Single route ▪ Overlapping ▪ Integrated Network System	▪ Reduced need for transfer		▪ Better definition of the brand if separated ▪ Widen exposure range if integrated in network			▪ Plans that are customer responsive attract ridership and max the system benefits	▪ Dependent on level of investment in running way infrastructure
Station spacing ▪ Narrow spacing ▪ Wide spacing	▪ Less frequent spacing reduces travel time	▪ Less frequent spacing limits variation in dwell time					
Frequency of service	▪ Reduced waiting time with increased service frequency	▪ Limited service interruption with high frequencies		▪ Increased potential conflicts with other vehicles and pedestrians	▪ Increase of operation capacity		

Source: Adopted from Wright, 2003

[1]Dwell time delay here considers the relationship between dwell time at station and factors, such as number of passengers boarding and alighting, degree of crowdedness on vehicles, and the number of standees on a station platform

Annex 2 Study introduction letter and interview consent form

Introduction

I am conducting a study on the BRT in Dar es Salaam to gain insight on how stakeholders, their needs and concerns were and could have been engaged in the planning process to help gather information for the development of a spatial decision support tool. The focus is on the decision making process related to spatial problems of BRT project infrastructures location, allocation or relocation. Therefore my goal for the interview is to obtain information on what these problems were, the data used to support the decision making process by lead planners, how the likely outcome information was presented to the stakeholders and how stakeholders were engaged in the deliberating and generating alternatives for decisions making of these outcomes.

The aim is to identify the dominant spatial decision making problem in BRT planning that could benefit from a spatial decision support system as well as the type of data/information needed to develop it.
Your participation is important as you have experience in BRT planning and thus could offer this info in greater detail while clarifying what has already been documented in reports.
All information gathered is purely to be used for educational purposes and will be presented anonymously in cases that the researcher might find it useful to use your own words in writing up the research. You can decide whether or not to permit the words to be used in this way. The consent section exists for the same.
It is expected that the interview will take approximately 30-45 minutes.
Any questions?

CONSENT

- The study has been explained to me in a language that I understand. Questions I had about the study have been answered.
- I have been informed that it is my right to refuse to take part in the interview today and that if I choose to refuse I do not have to give a reason.

Circle choice

I agree to take part in the study:	Yes	No
I agree that my own words may be used anonymously in the report	Yes	No

Signature of participant:

NAME	SIGNATURE	DATE OF SIGNATURE

Signature of researcher taking consent:

I have discussed the study with the respondent named above, in a language he/she can comprehend.
I believe he/she has understood my explanation and agrees to take part in the interview.

NAME	SIGNATURE	DATE OF SIGNATURE

Annex 3 DART Respondent interview guide

DART RESPONDENT SECTION
ORGANIZATION/DEPARTMENT

1. **What role/roles did your department get involved in, in the Dar es Salaam BRT project?**
2. **What are some of the space related problems that stakeholders had with the BRT project?** *(Please specify)*
3. **What information/data was made available or used to help in the discussions over the concerns presented?**
4. **What decision making strategies were used in the stakeholder collaboration sessions?**
5. **Which strategies did you find satisfying in addressing the concerns stakeholders had with spatial related issue that they expressed?**
6. **What information was NOT made available that you feel was essential to helping in the decision-making process as a stakeholder?**
7. **Which key institutions that you collaborated with in the planning of the BRT could you categorize as:**
   Primary Stakeholder - are those who are positively or negatively affected by the project decision
   Key Actor - are those who have power or expertise in the project
   Intermediaries - are those who have an influence on the implementation of decisions
8. **What were the reasons for engaging them in the planning process?** *(Please specify)*
9. **Which groups in your opinion WERE NOT fully engaged in the BRT phase 1 project that should be, moving forward to other phases of the project?** *(Please explain and offer examples)*
10. **How would you rate the level of stakeholder's involvement in the BRT planning process?**
11. **How can the stakeholder involvement process in addressing space related issues and tasks in BRT be handled more effectively moving on to the other phases?**
12. **How can you describe the level of using technology to support spatial planning activities with stakeholders?**
13. **Are you familiar with the concept of spatial decision support tools (SDSS) as technology tool that use Geographic Information System GIS and its related spatial data not only to manage data but also to facilitate decision making?**

Annex 4 Stakeholder interview guide

OTHER STAKEHOLDERS SECTION

ORGANIZATION/DEPARTMENT

1. **What role/roles did your organization/department get involved in, during the Dar es Salaam BRT project?**
2. **What were some of the space related problems that you had with the BRT project?** *(Please specify)*
3. **What information/data was made available or used to help in the discussions over the concerns presented?**
4. **What decision making strategies were used in the collaboration sessions?**
5. **Which strategies did you find satisfying in addressing the concerns you had with the space related issue that were experienced?**
6. **What information was NOT made available that you feel was essential to helping in the decision-making process as a stakeholder?**
7. **Which key institutions that you collaborated with in the planning of the BRT could you categorize as:**

Primary Stakeholder - are those who are positively or negatively affected by the project decision

Key Actor - are those who have power or expertise in the project

Intermediaries - are those who have an influence on the implementation of decisions

8. **What were the reasons for engaging them in the planning process?** *(Please specify)*
9. **Which groups in your opinion WERE NOT fully engaged in the BRT phase 1 project that should be, moving forward to other phases of the project?** *(Please explain and offer examples)*
10. **How would you rate the level of stakeholder's involvement in the BRT planning process?**
11. **How can the stakeholder involvement process in addressing space related issues and tasks in BRT be handled more effectively moving on to the other phases?**
12. **How can you describe the level of using technology to support spatial planning activities with stakeholders?**
13. **Are you familiar with the concept of spatial decision support tools (SDSS) as technology tools that use Geographic Information System GIS and its related spatial data not only to manage data but also to facilitate decision making?**

Annex 5 Closed ended questionnaire guide

In what areas of planning would you see the need of a spatial decision support tool for collaborative planning with stakeholders in BRT?

	No need for SDSS tool	Relative need for SDSS tool	High need for SDSS tool	Don't know
Display information of key urban land uses located within proposed BRT plans	○	○	○	○
Display social economic settings guiding BRT development plans	○	○	○	○
Display the social economic changes likely to be caused by BRT plans	○	○	○	○
Display relocation sites developed for BRT plans	○	○	○	○
Display effects of relocation to existing networks	○	○	○	○
Display environmental impacts likely to be caused by BRT plans	○	○	○	○
Monitor the status of travel behaviour change for BRT usage	○	○	○	○
Monitor land use changes from BRT plans	○	○	○	○
Monitor road network incidents	○	○	○	○
Monitor air quality status from BRT plans	○	○	○	○
Monitor hazards to water ecosystem since BRT	○	○	○	○
Monitor noise pollution status from BRT plans	○	○	○	○
Evaluate what are the costs and benefits of instituting or not instituting BRT plans	○	○	○	○
Analyse system perfomance on equitable transport access	○	○	○	○
Analyse suitability of spatial settings for BRT plans	○	○	○	○
Analyse suitability of alternatives BRT creates for other urban activites	○	○	○	○
Analyse land use changes due to BRT plans	○	○	○	○
Support analysis on what areas in urban region should be restricted for BRT development plans	○	○	○	○

Annex 6 Summary of interviews conducted

	Agency	Interview session				Complete	Incomplete
		Notes	Audio/Notes	Internet	Telephone		
1	DACOBOA	x					x
2	DART(Operations deprtment)	x				x	
3	DART (Social studies department)	x				x	
4	DART(Transport and development department)	x				x	
5	DAWASA (Program delivery)		x			x	
6	DAWASA (International consultant)		x			x	
7	DAWASCO				x		x
8	Former Dar City Council officer		x			x	
9	Interconsult		x			x	
10	Kinondoni Municipal Officer		x			x	
11	LEAT			x			x
12	NEMC		x			x	
13	NIT		x			x	
14	NIT		x			x	
15	SUMATRA	x				x	
16	TANESCO Kinondoni south		x			x	
17	TANROADS (Project engineer)		x			x	
18	TANROADS ()			x		x	
19	Traffic Police (field officer)		x			x	
20	TTCL			x			x
21	UDART		x			x	
22	University of Dar es Salaam			x			x

Annex 7 Documents provided from field work interviews by DART and Interconsult

- DART_ DataCollection _report
- DART_DSM_Public Transport_Background
- DART_ESIA-Report Final_Read
- DART_ExecutiveReport_February_09
- DART_ImpactAnalysisMitigation_RAP_report
- DART_ISP_schedule_2015Report
- DART_OperationalDesign_report
- DART_Parking_Management_Report
- DART_PhysicalDesign4Non Motorized_Disabled Integration
- DART_Planning the project presentation
- DART_WorldBank_RAP for Ubungo termianl 2015
- DART_WorldBank_RAP Temeke

Annex 8 Compilation of data provided from field and ITC

THEME	DESCRIPTION	TYPE (POINT, LINE, POLYGON, RASTER)	FORMAT	AVAILABLE Y-yes N-no
ADMINISTRATIVE	GIS file of Dar es Salaam district	polygons	shp	Y
	GIS file of Dar es Salaam wards	polygons	shp	Y
	GIS file of municipality boundaries	polygons	shp	Y
	General development zoning plans			N
CENSUS/ DEMOGRAPHICS	Census block population	csv	excel	Y
	Number of working population			N
	Number of households with cars			N
	Low income population zones	report, image	listing	Y
	Medium income population zones	report	listing	Y
	High income population zones	report	listing	Y
DEVELOPEMENT ZONES	Business estabilshment/commercial zones	polygon	shp	Y
	Residential zones	polygon	shp	Y
	Industrial zones	polygon	shp	Y
	Educational zone	polygon	shp	Y
	Development zones- areas not protected from development	polygon	shp	Y
	Activity density ([commercial buildings + housing units]/land area)	polygon	shp	Y
PUBLIC WELFARE	Location of accident zones			N
TRANSPORTATION	Dar es Salaam road network density	line	shp	Y
	Proposed BRT routes	image	pdf	Y
	Proposed integreted bike lanes	image	pdf	Y
	BRT bus stop location	point	shp	Y
	BRT bus terminals	point	shp	Y
	BRT depot stations	point	shp	Y
	BRT space allocation			N
	Reports on traffic volume			N
ENVIRONMENTAL	Dar rivers and streams	line	shp	Y
	Dar water bodies	polgon	shp	Y
	Air quality assessment			N
	Traffic noise population			N
	Green spaces/zones	polygon	shp	Y
UTILITY INFRASTRUCTURE	Electricity transmission lines	lines	shp	Y
	Electricity transformers	point	shp	Y
	Water supply network	line	autocad	Y

Annex 9 Different paratransit modes in DSM

Daladala Bus

Bodaboda Motorbike and minitrucks

Bajaji three wheelers

Annex 10 SPSS descriptive analysis results and frequency tables

		SDSS_Need_D_ExisitngLandUse	SDSS_Need_D_SocialEcon_BRT	SDSS_Need_D_SocialEconChanges	SDSS_Need_D_LocationSites	SDSS_Need_D_RellocatEffects	SDSS_Need_D_EnvironImpacts	SDSS_Need_M_TravelBehavChange	SDSS_Need_M_LandUseChange	SDSS_Need_M_RdNtwkIncidences
N	Valid	17	17	17	17	17	17	17	17	17
	Missing	0	0	0	0	0	0	0	0	0
Mean		3.41	3.53	3.71	3.71	3.59	3.53	3.65	3.71	3.53
Std. Deviation		.618	.514	.470	.772	1.004	.514	.786	.772	.624
Minimum		2	3	3	1	1	3	1	1	2
Maximum		4	4	4	4	4	4	4	4	4

		SDSS_Need_M_AirQuality	SDSS_Need_M_WaterEcosysem	SDSS_Need_M_NoisePollution	SDSS_Need_A_CBA	SDSS_Need_A_EquityPerformance	SDSS_Need_A_BRTSpatialSusitability	SDSS_Need_A_RelocationSuitability	SDSS_Need_A_LandUseImpacts	SDSS_Need_A_BRTRestrictins
N	Valid	17	17	17	17	17	17	17	17	17
	Missing	0	0	0	0	0	0	0	0	0
Mean		3.00	3.47	2.76	3.76	2.94	3.41	3.71	3.65	3.71
Std. Deviation		.866	.514	1.033	.562	1.029	.795	.772	.493	.470
Minimum		1	3	1	2	1	1	1	3	3
Maximum		4	4	4	4	4	4	4	4	4

_ExisitngLandUse		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No need	1	5.9	5.9	5.9
	Neutral	8	47.1	47.1	52.9
	High need	8	47.1	47.1	100.0
	Total	17	100.0	100.0	

SocialEcon_BRT		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Neutral	8	47.1	47.1	47.1
	High need	9	52.9	52.9	100.0
	Total	17	100.0	100.0	

SocialEconChanges		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Neutral	5	29.4	29.4	29.4
	High need	12	70.6	70.6	100.0
	Total	17	100.0	100.0	

_LocationSites		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Dont Know	1	5.9	5.9	5.9
	Neutral	2	11.8	11.8	17.6
	High need	14	82.4	82.4	100.0
	Total	17	100.0	100.0	

_RellocatEffects		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Dont Know	2	11.8	11.8	11.8
	Neutral	1	5.9	5.9	17.6
	High need	14	82.4	82.4	100.0
	Total	17	100.0	100.0	

_EnvironImpacts		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Neutral	8	47.1	47.1	47.1
	High need	9	52.9	52.9	100.0
	Total	17	100.0	100.0	

TravelBehavChange		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Dont Know	1	5.9	5.9	5.9
	Neutral	3	17.6	17.6	23.5
	High need	13	76.5	76.5	100.0
	Total	17	100.0	100.0	

_LandUseChange		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Dont Know	1	5.9	5.9	5.9
	Neutral	2	11.8	11.8	17.6
	High need	14	82.4	82.4	100.0
	Total	17	100.0	100.0	

_RdNtwkIncidences		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No need	1	5.9	5.9	5.9
	Neutral	6	35.3	35.3	41.2
	High need	10	58.8	58.8	100.0
	Total	17	100.0	100.0	

_AirQuality		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Dont Know	2	11.8	11.8	11.8
	Neutral	11	64.7	64.7	76.5
	High need	4	23.5	23.5	100.0
	Total	17	100.0	100.0	

_WaterEcosysem		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Neutral	9	52.9	52.9	52.9
	High need	8	47.1	47.1	100.0
	Total	17	100.0	100.0	

_NoisePollution		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Dont Know	3	17.6	17.6	17.6
	No need	2	11.8	11.8	29.4
	Neutral	8	47.1	47.1	76.5
	High need	4	23.5	23.5	100.0
	Total	17	100.0	100.0	

_CBA		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No need	1	5.9	5.9	5.9
	Neutral	2	11.8	11.8	17.6
	High need	14	82.4	82.4	100.0
	Total	17	100.0	100.0	

EquityPerformance		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Dont Know	3	17.6	17.6	17.6
	Neutral	9	52.9	52.9	70.6
	High need	5	29.4	29.4	100.0
	Total	17	100.0	100.0	

'SpatialSusitability		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Dont Know	1	5.9	5.9	5.9
	Neutral	7	41.2	41.2	47.1
	High need	9	52.9	52.9	100.0
	Total	17	100.0	100.0	

_RelocationSuitability		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Dont Know	1	5.9	5.9	5.9
	Neutral	2	11.8	11.8	17.6
	High need	14	82.4	82.4	100.0
	Total	17	100.0	100.0	

_LandUseImpacts		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Neutral	6	35.3	35.3	35.3
	High need	11	64.7	64.7	100.0
	Total	17	100.0	100.0	

BRTRestrictins		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Neutral	5	29.4	29.4	29.4
	High need	12	70.6	70.6	100.0
	Total	17	100.0	100.0	

Annex 11 Iterative results of the pairwise comparison for vision weights

ORIGINAL STAKEHOLDER				weights
Insitiutional	0.26	integrate non-motorized modes (walking)	0.67	0.17
		in dense activity areas	0.33	0.09
Technical	0.28	upgrading exising bus stops	0.35	0.10
		available space in primary roads	0.41	0.11
		relatively available space in sec. roads	0.19	0.05
		limited space in tertiary roads	0.05	0.01
Economic	0.29	less buildings to compensate	1	0.29
Social	0.12	Service to high population areas	1	0.12
Environmental	0.05	located away from rivers	1	0.05

EQUAL VISION				
Insitiutional	0.20	integrate non-motorized modes (walking)	0.67	0.13
		in dense activity areas	0.33	0.07
Technical	0.20	upgrading exising bus stops	0.35	0.07
		available space in primary roads	0.41	0.08
		relatively available space in sec. roads	0.19	0.04
		limited space in tertiary roads	0.05	0.01
Economic	0.20	less buildings to compensate	1	0.20
Social	0.20	Service to high population areas	1	0.20
Environmental	0.2	located away from rivers	1	0.20

SOCIAL VISION				
Insitiutional	0.20	integrate non-motorized modes (walking)	0.67	0.19
		in dense activity areas	0.33	0.09
Technical	0.20	upgrading exising bus stops	0.35	0.09
		available space in primary roads	0.41	0.11
		relatively available space in sec. roads	0.19	0.05
		limited space in tertiary roads	0.05	0.01
Economic	0.20	less buildings to compensate	1	0.12
Social	0.20	Service to high population areas	1	0.29
Environmental	0.2	located away from rivers	1	0.05

ENVIRONMENTAL VISION				
Insitiutional	0.20	integrate non-motorized modes (walking)	0.67	0.19
		in dense activity areas	0.33	0.09
Technical	0.20	upgrading exising bus stops	0.35	0.04
		available space in primary roads	0.41	0.05
		relatively available space in sec. roads	0.19	0.02
		limited space in tertiary roads	0.05	0.01
Economic	0.20	less buildings to compensate	1	0.05
Social	0.20	Service to high population areas	1	0.26
Environmental	0.2	located away from rivers	1	0.29