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Effects of Land Use Forms and Pattern on the Demand for Public transport (The case of Addis Ababa, Asko – Merkato- Piassa Corridor)

A Thesis submitted to

School of graduate studies of Addis Ababa Institute of Technology, as a partial fulfillment of the requirements for the Degree of Master of Science in Civil Engineering

By

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This is to certify that the thesis prepared by Ashenafi Daba, entitled: ***Effects of Land Use Forms and Pattern on the Demand for Public transport (The case of Addis Ababa, Asko – Merkato-Piassa Corridor)*** andsubmitted as a partial fulfillment of the requirements for the Degree of Master of Science complies with the regulations of the university and meets the accepted standards with respect to originality and quality.

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ABSTRACT

Integrating land use planning with transport developments is one of the major statements of Addis Ababa city road transport policy. However, the existing literatures support that the current public transport system is inefficient, ineffective and inaccessible because of lack of coordination between land use and transport planning.

The current demand and supply of public transport of the Addis Ababa city varies over space and time. It has been hypothesized that this variation emanates from the way the activities are distributed within the city. Distributions of activities are expressed by land use mix, population density and centeredness for this study as the main factors.

This study applied a simple descriptive statistics and Factorial Analysis approach to investigate the relationship between change in public transport demand and land use characteristics in Addis Ababa at a corridor level. The average relationship between the land use form and change in demand for public transport in Addis Ababa has been identified and used to investigate the spatial variability of this relationship.

Traffic Analysis of different land use mix level , population density and centeredness have been developed and direct travel demand by public transport has been measured to test the variation. Considerable variation in demand has been observed between two TAZs with different independent variables.

ANOVA was employed and significant correlation have been observed between the land use mix level, population density, centeredness and change in demand for public transport.

Key Words: *Public Transport, Land use Mix, Demand for public transport, Change in demand Population density, Centeredness*

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

GLOSSARY OF ACRONYMS

A_{TAZ} …………………………………………. Area of the Traffic Analysis Zone

A_w ……………………………… Area of the woreda in which the TAZ is located

A – M ……………………………………………………..………Asko to Merkato

A – P ……………………………………………………………………Asko to Piassa

A – PM ……………………………………...……Asko to Paulos Medhanialem

C ………………………………………………………………………Centerdenss

CBD ………………………………………………………..Central Business District

KMO ……………………………………………………Kaiser – Meyer – Olkin

LDP ………………………………………………..Local Development program

MUDC …………………………Ministry of Urban development and construction

P_{TAZ} ……………………………………………………..Population of the TAZ

P_W ……………………………………………………Population of the Woreda

TAZ ……………………………………………………Traffic Analysis Zone

Chapter One

Introduction

1.1. General Overview

The demand for transport is driven by the need for people to reach locations where activities take place, including the workplace, schools, hospitals and clinics. Therefore, effective land-use planning is vital, as it determines where major facilities and human settlements are located, how far people have to travel to access such facilities, and what households and government spend on transport (Sabelo M.tantato,2012/13).

The current public transport system of the city is inefficient, ineffective and inaccessible, while coordination is lacking between land-use patterns and transport planning. In urban areas, the demand for houses and for suitable land on which to build housing is increasing, but well-located land is scarce, costly. As a consequence, most low-cost housing projects tend to be developed in semi-urban areas, where land is cheaper, readily available and can be accessed with relative ease. Given the relative scarcity and cost of land in urban areas, cities need to make the most efficient use of this resource once it becomes available.

The study reviews the adequacy of existing guidance on the ways in which urban forms and the working planning practices influences the public transport demand and identifies barriers that may be hindering better decision-making and explores possible solutions.

The relationship between public transport demand and land use characteristics has been extensively examined in the existing literature. It has also been well recognized that the land use characteristics in a built environment can be categorized into land use density, diversity (mix), centeredness, roadway connectivity and accessibility (Cervero, R.,and K.Kockleman,1997).

This paper provides statistical evidence of the relationship between public transport demand and land use characteristics as an evidence base for how public transport use can be efficient, increased and promoted through strategic urban planning.

Although the relationship between public transport demand and land use has been identified in the existing literature, there is a lack of micro-analysis which comprehensively incorporates all the land use factors in the public transport demand model, together with other key determinants such as price and socio-economic factors. Previous studies, based on the regional level (e.g. cities; states; countries), have not been able to provide insights into spatial variation of different variables across local communities on public transport demand for a specific study area. Furthermore, the relationship between demand and land use has been conventionally examined at an average level assuming a homogenous parameter across all observations, without taking the spatial variability of land use variables into consideration. The spatial variability is important because it indicates a heterogeneous association between public transport demand and its determinants in the local areas, which provides important policy implications for local transport and urban planning.

This paper applies a simple descriptive statistics and Factorial Analysis approach to investigate the relationship between change in public transport demand and land use characteristics in Addis Ababa at a corridor level. The average relationship between the land use form and change in demand for public transport in Addis Ababa has been identified and used to investigate the spatial variability of this relationship.

1.2. Background of the Problem

Addis Ababa is an old city undergoing major construction projects. These include the transport infrastructures, the housing development projects owned by the public (government), the real estate projects and industry zones.

The Light Rail Transit is constructed to pass through east – west(Ayat – Tor Hayloch) and south – north(Merkato- Piassa- kaliti) corridor of the city, while the roads are open for traffic under construction and design to modify the network , for better mobility and accessibility.

The housing development projects, real estates and industries are located at the sub urban parts of the city. There are two major market (commercial) areas in the city, namely Merkato and Sholla. At other locations of the city it is common to see shops along roads and streets of the city. Offices and schools are randomly distributed in the city and there is no coordination between these land use forms and locations with the public transport lines or corridors.

With the above nature of land use forms and policy, and current socio economic feature of the city, it is becoming common to see lines of people along streets and at the terminals of public transport, waiting to be served, especially, during the peak hours. While the passengers are waiting for the public transport vehicles around their residences, the vehicles on the other hand wait for the passengers at other form of land use (urban centers or mixed use form of land use) and vice versa. Queue of passengers is formed at different locations at different times of a day. This means demand and supply changes their location with time. It has been hypothesized that this variation of demand and supply over space and time is because of the land use pattern and the way activities are distributed.

1.3. Research Objectives

The general objectives of this research is to statistically examine and test the impact or effect of current land use patterns, planning policy and practices on the demand for public transport in Addis Ababa. The specific objectives of this study (research) are;

- ✓ To examine the trip interchange between TAZs of different land use form and pattern
- ✓ To evaluate the effect of current land-use factors such as mix and centeredness and on the demand for public transport;
- ✓ To evaluate the way the demand for public transport varies with land use pattern
- ✓ Asses spatial variation of demand and supply of public transport in relation to the land use forms

1.4. Limitation of the Research

The following are the major limitations of this study;

- The demand for LRT has not been included
- Emphasis was given more of to the demand side; the supply side has not been treated well.
- No pilot survey has been done to support the research background

1.5. Significance of the Research

It has been set that the main purpose of this study is show how the land use patterns and distribution of activities affect the amount and direction of public transport demand. Depending on the nature of the research results and analysis out put the following are the main significances of this study.

- In put for policy makers, whenever it is needed to promote public transport.
- To solve the current transport problems by working on the land use mixing and distribution of activities (Short Term)
- Urban planners can use this finding as an input while coordinating land use developments with transport demands.
- To figure out nature of public transport demand over space and time for policy interventions or, for any kind of current use.

1.6. Scope and Organization of the Thesis

This thesis work has been compiled in to five main chapters. This first chapter is more of introductory, addressing the issue of limitations, scope, objectives, research back ground and significances of the study. The second chapter presents the review of the supporting existing literatures. The research methodology has been explained in the third chapter of the paper. The last two chapters' deal with the summary of research finds, results and Conclusions and recommendation of the work.

Chapter Two

Literature Review

2.1.General Overview

2.1.1. The nature of land use in Addis Ababa

For effective urbanization and organized urban development, a well thought urban planning exercise is a prerequisite. Besides, urban areas need development strategies tailored to the geographical and demographic specificity's of their local areas. To this end, exploring the status of land use significantly helps for strategic urban planning that matches with the available resources in line with the requirements of the rapidly increasing population. In other words, effective land management helps to equate the supply of land with the demand for different functions such as industry; housing, commerce and the like. (BOFED of Addis Ababa, UDI, August 1998)

Even though land is the largest economic resource of Addis Ababa, the land use pattern is characterized by haphazard development which mainly geared towards horizontal expansion.

Particularly, most of the riverside areas in the city are not well kept and utilized as per the acceptable standard. Out of the entire 54,000 hectare of the city's land, built-up area comprises

31.3%, green area (forest, riverside greens etc) accounts for 23.4%, existing agriculture area 13.8%, proposed mixed use expansion area 13.4%, existing industries 2.4% and social services account for 1%.

Table 2.1. Land use categories and share for Addis Ababa

No.	**Land use categories**	**Area (Hectare)**	**Percentage share**
1	City Centers (CBD)	1317	2.4
2	Forest	12647	23.4
3	Agriculture	7453	13.8
4	Existing Industry	1292	2.4
5	Proposed Industry	1846	3.4
6	Mixed use built up	16,900	31.3

7	Proposed social service	624	1.2
8	Existing Social service	514	1
9	Reserved	1085	2
10	Transport	1029	1.9
11	Mixed use expansion	7243	13.4
12	Road network (Arterial Streets only)	2050	3.8
	Total	**54,000**	**100**

2.1.2. Public Transport Demand and Supply in Addis Ababa

Addis Ababa, the capital city of the Federal Democratic Republic of Ethiopia, is located in the center of the country. Established in 1886, the city has experienced several planning changes that have influenced its physical and social growth. The area of Addis Ababa is 530.14 square kilometers. Its current population is about 3.0 million (2010 estimate), about 4.5 percent of the population of Ethiopia. It also represents about 26 percent of the urban population of Ethiopia. Addis Ababa has an aggregate population density of 5,660.8 persons per square kilometer.

Public transport in the city consists of conventional bus services provided by the publicly owned Anbessa City Bus Enterprise, taxis operated by the private sector and buses used exclusively for the employees of large government and private companies. The role of bicycles in urban transport is insignificant (World Bank African Region Scoping Study 2002). The road network of Addis Ababa is limited in extent and right of way. Its capacity is low; on-street parking is prevalent.

In the city of Addis Ababa, the dominant public transportation modes are city buses and taxis. Although buses have 30 seats each, they have a carrying capacity of 100 people in a crowded situation. Taxis have a carrying capacity from four (small taxis) to 12 persons (large taxis). Car ownership among residents is very low, so the majorities depend on buses and taxis for their day-to-day mobility. Walking is the main means of transportation for a number of residents. Unlike other cities in the country, bicycle use is insignificant because of topographic inconveniences.

Buses provide 40 percent of the public transport in the city; taxis account for 60 percent (Ethiopian Roads Authority 2005). The city is currently experiencing horizontal growth, but the bus service has not exhibited growth proportionate enough to accommodate this increase. Analysis results of the transit availability indices show that only the city center is being served by the existing bus networks while urban expansion areas have low transit availability (Mintesnot and Takano 2006).

Taxis experience many operating constraints, including bad driver behavior, excessive fares, and high accident rates

Spatial analysis of the bus network coverage shows that only the city center, which is where commercial activities are abundant, boasts high bus network availability. Areas with low or no bus network availability are in localities where the city is exhibiting trends in urban expansion and where residential developments are underway. According to the recent structural synthesis map, prepared by the Addis Ababa Master Plan Revision Office, those sections are strategic areas for city expansion development (Office of the Revision of Addis Ababa Master Plan 2002).

The demand for the bus in the city can be summarized by the following figure.

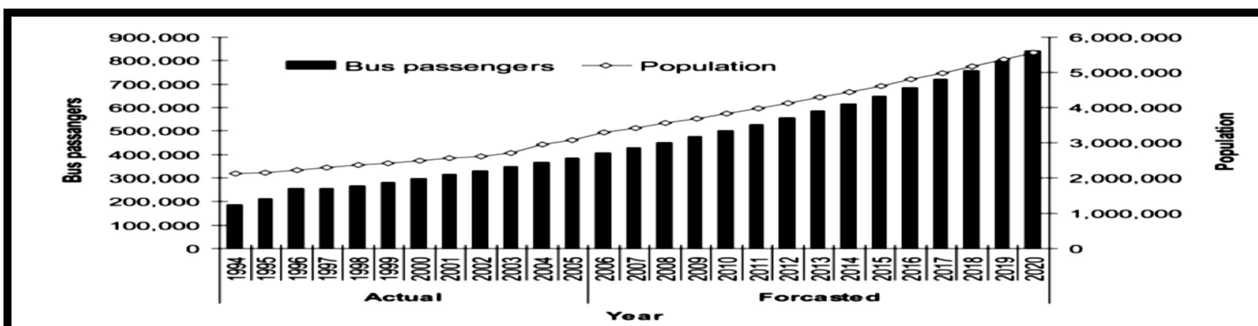

Figure 2.1. The demand for the bus mode

Source, Ambessa city bus Enterprise and Central Statistics Agency

2.2. Interaction between Land Use and Transportation

2.2.1. Introduction

2.2.1.1 Definitions

According to UK transport guidance module, 2014, “Land use Transport Interaction”, the term ***land use*** is defined as a range of human activities, the state of the built environment, and also to some aspects of natural environment. Having this definition, land use is of relevance to transport for at least three reasons,

- Land using activities and the interaction between them generate the demands for transport
- Those activities and interactions are to greater or lesser extent influenced by the availability of transport; and
- The linkages between transport and activities may be important to the appraisal of transport strategies- especially when trying to consider whether the transport system is influenced by the land use activities

In speaking of land use, travel demand modelers often are simply using this term as a shorthand expression for the zonal population and employment distributions that they require as inputs to their models. More formally, land use refers to the way in which land is used, in terms of the buildings built upon the land (houses, stores, schools, factories, etc.) and the activities housed within these buildings (in-home activities, shopping, education, work, production of goods and services, etc.). As such, land use is essentially synonymous with urban form, which is a term often used by geographers and regional scientists. Given that it is the participation in out-of-home activities that gives rise to the need for travel, transportation system analysts often speak of the urban activity system, which consists of both the physical built form and the spatial–temporal distribution of activities that occur within this built form(Konstandinos G. Gaulias,2008)

Litman, on his paper published in 2010, categorized land use as follows,

Table 2.2 Land use Categories

Built Environment	***Open Space***
Residential	Agriculture
Commercial	Forest
Industrial	Undeveloped lands
Brown fields(for infill development)	

Transport Facilities	

Land-use patterns can be evaluated based on a number of attributes (Litman, 2010):

- *Density level*: the number of people or the number of housing units within an area.
- *Mix of land-use types*: such as the location of commercial, residential and other important amenities together or close to each other, which is also related to clustering.
- *Accessibility*: the ability of people to be able to reach their desired activities and destinations
- *Green space*: the portion of land used for parks, gardens, etc.
- *Non-motorized accessibility:* the availability and quality of walking and cycling conditions.

Public transport

Public transport demand in this study/ paper is defined as the average number of public transport trips made by a traveler (i.e. a traveler refers to a respondent making at least one trip using any trip mode) in a day from/to an analysis Zone.

2.2.1.2. Interaction between Land Use and Transportation

Land use and transportation are two sides of the same coin. Transportation affects land use and land use affects transportation. Decisions that affect one also affect the other. As a result, it is important to coordinate transportation and land use planning decisions so they are complementary rather than contradictory. This insures that transport planning decisions support land use planning objectives and land use planning decisions support transport planning objectives. This requires an understanding of how specific land use patterns affect travel (Todd Litman, 2005)

2.2.2. Land use planning practices and policies

Urban planning is one of the most important tools of urban management. It guides the socioeconomic and spatial/physical development of a given urban center. Hence, urban development effort without the guidance of urban planning is like walking blindfolded.

Ethiopia is not only least urbanized but also most urban centers in the country are predominantly unplanned. A naked eye observation on current urban morphologies suffices to retrace the minimal role of planning in the Ethiopian urbanization process. This predominance of unplanned development in Ethiopian urbanization poses a substantial need for re-planning in all urban centers of the country. The re-planning involves an extensive land-use readjustment, fundamental reorganization of infrastructure networks as well as revitalizing run down urban fabrics. In this respect, LDPs play key roles, since wholesale interventions are both unfeasible and unadvisable in built up urban areas.

LDP (Local Development Plan) is a lower level urban plan, which is prepared within the framework of a structure plan. It is detailed and focuses on specific locality of an urban center for immediate implementation. It is therefore, an important tool for implementation of structure plan proposals.

The preparation of LDPs in Ethiopia has a very brief history. Moreover, it is limited to few urban centers. The methodology has been informal, lacking systematized approaches. The approaches, pursued by the LDPs prepared for various localities in Addis Ababa are not similar due to the fact that there are no standardized guidelines. This has significantly affected the quality of the local development plans so far prepared and impeded their effective execution. Evidently, most of the LDPs prepared for the various localities of Addis Ababa are either left on shelves or wrongly implemented.

The knowledge gap in the preparation of LDPs in Ethiopian urban centers has necessitated the preparation of simplified LDP preparation and implementation Manual. The manual attempts to standardize the spontaneously used LDP preparation knowledge and techniques. More importantly, the manual preparation has adopted the recently introduced IDP approach in order to secure strong public participation and integrated development efforts of urban centers.

The LDP in the context of Ethiopian Urban Planning System can be summarized by the following Figure,

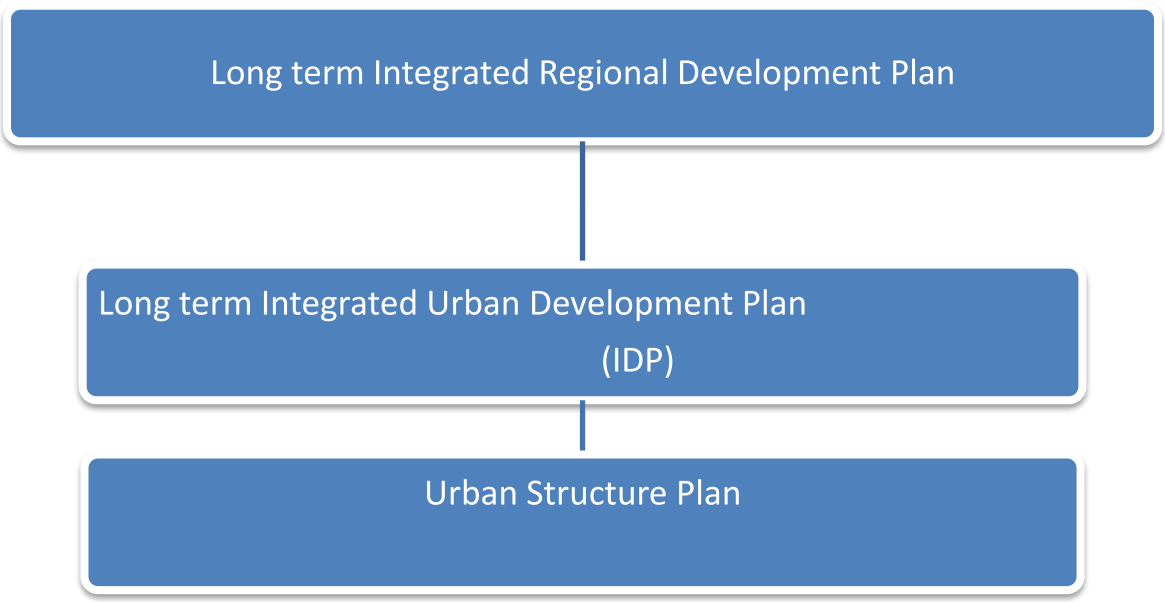

Figure 2.2 Structure od Ethiopian Urban Planning System

Currently, land use planning practices of Addis Ababa is as per the Structure Plan Manual of the Ministry of Urban Development and Construction, 2012. According to the manual, the following steps has been followed to develop the conceptual plan

- ✓ Identification of the spatial development trend of the town;
- ✓ Indicating the existing built-up area showing main elements(manufacturing and storage related activities, services, administration, and commercial activities)
- ✓ Indicating future development/ expansion areas incorporating main elements
- ✓ Indication of major roads integrating future expansion areas and existing built up area.
- ✓ Indicating main center and sub-centers clearly.
- ✓ Indicating urban redevelopment intervention areas of the urban center
- ✓ Identify land use zoning

Steps for the determination of future land use budget

1. Get the additional number of households during the planning period from the demographic analysis
2. Obtain average plot size to be delivered (the region's policy)
3. Based on the plot size calculate the total area required for residential purpose

4. Add 20% contingency including road and other services
5. Assuming that the area for residence constitutes 50 percent of the total area required for expansion, calculate the land required for other purposes which is obviously 50%

The proposed portion of each type of land use, according to the manual can be summarized by the following table

Table 2.3 Ideal Proportion (share) of land use categories

Components of Structure Plan	Proposed Percentage
Housing (Residential)	55-70
Business and commerce/ Centers and market places	5-10
Public facilities, cultural, archaeological sites and special functions	5-10
Manufacturing/ Industry and storage	5-10
Infrastructure, utilities and transportation	15-25
Infrastructure, utilities and transportation	15-20

Additionally, the major contents of Land use categories and prohibited uses are given on the manual by the following table

Table 2.4 major Contents of land Use Categories

Land use Category	Major Contents of the category	Prohibited uses
Housing	• All types of residential developments • Educational services: kindergarten to secondary schools • Health services: health post to health center • Neighborhood markets ('Gulits') and shopping areas • Small and medium scale Manufacturing and warehouses • Recreation and entertainment centers • Small Administrative offices, business • Worship places	Large scale industries, storage and warehouses, Military establishments and ammunition stores; Waste treatment plants and landfill sites; Cemeteries; Transport terminals; Quarries Universities, colleges, hospitals, stadiums
Business and commerce/ Centers and market places	• Shops • Markets • Centers of different hierarchies • Administrative uses • Banks • Insurances	Large scale industries, storage and warehouses; Cemeteries; Waste treatment plants and landfill sites; Military establishments and stores; and Quarries
Public facilities, cultural, archeological sites and special functions	• Education (colleges, universities) • Health (health center, hospitals) • Community facilities • Municipal services	All except services defined within the same category
Open spaces and environmental sensitive areas	• Open space for outdoor recreation; necessary for the preservation of natural resources; • Open space for the managed production of resources; • Open space reserved for public safety against risks from environmental elements; • Open space for future expansion; Right-of-ways reserves for future upgrading of road size	All activities except for direct uses designated and part of the environment project; any urban built up activity more than 25 % coverage in parks and green recreation areas
Administrative	• Governmental institutions • NGOs • Police • Justice • Correctional Institutions	Mainly not far from central areas except in the case of correctional institution
Manufacturing and storage	• Industry and manufacturing • Warehouse, depots	All except services defined within the same category

2.2.3. Transport Policy

Providing comfortable, safe, dependable, efficient, equitable transport service for the city of Addis Ababa is a condition to accelerate the development of the city, and make a competent city on regional, continental and international levels. The provision of implementable policy and strategy is a key factor to the stated needs.

In order to accomplish these needs, the Transport Policy of Addis Ababa has outlined eleven key policy issues and implementation strategies (Transport policy of Addis Ababa ,2010).

One of the key policy issues is "*Integration of Land-use and Transport Plan*", with the objective of ensuring coordinated implementation of the city development plan and transport infrastructure and service plan; promote interdependent overall city and urban transport development.

The policy has also detailed policy statements and corresponding policy measures to integrate land use and transport development plans.

2.2.4. Definition of Urban forms and urban spatial structures

Learning how cities work and why they are spatially organized as they are, is the key to answering many questions about the interaction between the structure of cities and travel patterns. A number of research works involve attempts to obtain a good understanding of what is meant by both terms urban form and spatial structure.

The three key terms mentioned in the literature to define urban structure are:

1. Urban form. or Form
2. Urban interaction. or Function
3. Urban spatial structure. or Structure.

Urban form is the spatial pattern or arrangement of individual elements such as buildings and uses, as well as a social group of economic activities and public institutions within urban area. Alternatively, ***Form*** is the physical pattern of land use activities. Population distribution and the networks linking them (Amal Ibrahim ,1997).

Urban interaction is the underlying set of interrelationships, linkages and flows that act to integrate the pattern and behavior of individual land uses, groups and activities into functioning entities.

Alternatively, ***Function*** is the activity undertaken and the movement of flow necessary to share that activity.

The term **urban spatial structure was** discussed in early attempts made by Post (1964) and Von Boventer (1962). Post referred to spatial structure as changes in, and arrangement and extension of urban form, While Von Boventer defined spatial structure as spatial distribution of producers of various goods and services and consumers in cities and town of various sizes. Alternatively, **Structure** is the combination of form and function. In system terms, form refers to interdependent parts, road network, houses, stores, parks, etc... And function refers to the interrelationships, why and how people, goods and messages move or flow between parts.

2.2.5. Elements of Urban forms and urban spatial structures

Researchers looked broadly at urban spatial structure from different perspectives such as economics, politics, social psychology, political, economy, human ecology, physics and engineering. For the sake of this study, discussion will be limited to the combination of both urban form and the overlay of patterns of travel behavior and interaction into the city system.

2.2.5.1.Main characteristics of Urban forms

Urban form was defined on different levels of complexity in Berry's work (1974). First, microscopically, in terms of detailed location of jobs, residences, commercial areas, recreation areas and vacant non-urban land, with particular attention to location of heavy polluting facilities (power stations). Second, at a higher level of generalization, urban form can be specified in terms of density of activities and elements, separate of uses, type and structure of transportation network and time dimension of the utilization of its space. Third, at the most generalized level urban form may be approached in terms of spatial configurations: compact versus dispersed, single nuclei versus multi-nuclei and form that adapt to growth or those which have predetermined size.

The three traditional models of urban structure described in the literature were based on the spatial configuration of the city as follows: concentric, radial and multiple nuclei models specifications of urban form. Description of these models was included in work done by Rice (1978) as follows:

Concentric city: The CBD is location with maximum employment density, maximum number of trip ends and maximum rent. Land uses are segregated in the form of concentric zones around the CBD.

Radial City: Transportation network consists of a small number of major routes that extend out from the CBD. Also, land uses extend out from the CBD along major lines of transportation. A special case of this form is the linear city, in which there is only one transport line with the CB D located at its centre

Multinucleated city or polycentric city: The CBD is the dominant focal point of the city but there are also other local focal points of high employment density, trip ends and rent.
The transportation system is more complex and not al1 routes are oriented toward the CBD.
This form is characterized with a higher overall level of connectivity in the city.

2.2.5.2.Characteristics of Urban spatial structures

The term urban spatial structure was extended to represent various attributes as follows (Bourne, Mackinnon and Simmons. 1973):

1. Land use distribution and arrangement.
2. Organization, concentration and intensity of activities and human occupancies.
3. Formal networks of interaction, flows and communication linking human behavior and physical artifacts.
4. Decision-making powers.
5. Values and norms interwoven with the above physical attributes

2.3.Land use factors affecting the Demand for Public Transport

Public Transport Demand is affected by the land use and city built environments. The relationship between land use and public transport are complex, each being directly dependent on the other and this complexity is enhanced by interaction with other factors including age distribution, employment characteristics, income levels and car ownership. Hence it is difficult to establish the precise relationship between PT demand and land use patterns (Balcombe et, al, 2004).

The built environments, investigated in three basic dimensions in the literature, namely "density", "diversity", and "design", called "3Ds", shape the travel behavior. Compact neighborhoods can deteriorate the need for private vehicle trips and even encourage non-motorized or PT modes in a few ways: Bringing origins and destinations closer, there become more opportunity for leaving one's car at home and walking or cycling to a destination or using PT vehicles. Compact neighborhoods moreover tend to have less parking, better quality transport services, wider mixes of land uses and larger shares of low – income households, all of which reduce car use and increase alternative modes. All these characteristics of trips ends affect travel behavior and choices (cervero and Kockleman ,1997; Balcombe et,al,2004).

Merging housing, shopping, employment and other facilities in mixed –use developments provide residents with the opportunity to live, work, and carry out other daily activities locally or with the minimum travel needs, without having to drive (Balcombe *et al., 2004).*In fact, travel demand is a derived demand in the sense that trips are made and distributed on the basis of the desire to reach places, whether office buildings,ballparks, or shopping centers. The characteristics of these places i.e, their land uses, densities, design features can affect not only the number of trips generated but also modes and route of travel. While characteristics of origin – destination interchanges…are known to affect travel demand, so are features of the trip ends (i.e., origins and destinations) themselves (Cervero and Kockleman, 1997).
Matas (2004) supports this by drawing attention that the higher population densities of (Spanish) cities make them better suited for PT use than to car use (Webster et al, 1986).

The Degree of centralization of employment and facilities (restaurants, shops, services, outlets, entertainments places.), as a design element, also influences travel behavior. A greater degree of centralization encourages PT use and reduces private car use. Distributed shopping centers around the city also reduces travel demand (cervero and Kockleman, 1997; Balcombe et al, 2004). Old European cities and newly established American cities are the typical examples of how city design affects the transport behavior. In the European cities, the PT use is higher than that in American cities, which have wider streets, more parking spaces, better – organized city planning, distributed shopping centers etc. compared to the old historical European cities, where those infrastructures are mostly under protection and cannot be modified for a better transport development. In such cities, PT systems are adapted into the current state of the city built environments and structures (*hovel and Jones*, *1975*).

Cervero and Kockleman (1997) found the effects of built environment on travel demand being modest to moderate at best for their case of study. Densities exerted the strongest influence on personal business trips. Diversity also had a modest impact on travel demand but a bit stronger than that of density. Design elements of built environment seemed to be particularly relevant to non – work trip making. The general conclusion was that higher densities, diverse land uses and pedestrian friendly designs… must co- exist to a certain degree if meaningful transportation benefits are to accrue.

In sum, the 3Ds are an important demand determinants but PT demand can be shaped to a certain extent by utilizing specific land use policies that could affect Pt use. Some policies may include the development of new residential areas, new commercial and industrial zones, mixed – use (e.g. Merged commercial and residential areas) development, car – free zones and transit oriented developments (Balcombe et al, 2004)

The relationship between public transport demand and land use characteristics has been extensively examined in the existing literature. The most frequently mentioned variables are,

- ✓ The location of houses, jobs ,jobs, and other opportunities in combination with infrastructure networks
- ✓ Densities of houses, employment and other categories of land use
- ✓ The level of mix the mix in land use categories

It has also been well recognized that the land use characteristics in a built environment can be categorized into land use density, diversity, urban design (known as 3D), and accessibility (Todd Litman, 2005).

Littman, 2005, defined different land use patterns referring to land use factors and summarized into the following table,

Table 2.5 Land Use patterns referring to land use factors

Factors	Definition
Density	People or jobs per unit of land area (acre or hectare).
Mix (Diversity)	Degree that related land uses (housing, commercial, institutional) are located together. Sometimes measured as *Jobs/Housing Balance*, the ratio of jobs and residents in an area.
Regional Accessibility	Location of development relative to regional urban center. Often measured as the number of jobs accessible within a certain travel time (e.g., 30 minutes).
Centeredness	Portion of commercial, employment and other activities in major activity centers.
Connectivity	Degree that roads and paths are connected and allow direct travel between destinations.
Roadway design and Management	Scale and design of streets, and how various uses are managed to control traffic speeds and favor different modes and activities.
Parking Supply and management	Number of parking spaces per building unit or hectare, and the degree to which they are priced and regulated for efficiency.
Walking and Cycling conditions	Quality of walking and cycling transport conditions, including the quantity and quality of sidewalks, crosswalks, paths and bike lanes, and the level of pedestrian security.
Transit quality and accessibility	The quality of transit service and the degree to which destinations are accessible by quality public transit in an area.
Site design	The layout and design of buildings and parking facilities.
Mobility Management	Various programs and strategies that encourage more efficient travel patterns. Also called *Transportation Demand Management*.

Public transport demand is affected by various factors. Balcombe et al. *(2)* and a meta-analysis reported by Holmgren *(3)* suggested that public transport fare and users‟ socio-economic factors should be taken into account in public transport demand models. Cervero and Kockelman*(1)* also concluded that the 3D (Density, diversity and design) of land use and accessibility have significant impacts on the public transport use. In principle, density generally refers to housing, population, or employment density. Diversity is used to illustrate the heterogeneity of land use and is normally measured as the entropy of the land mix. Urban design refers to the connectivity and walkability in a neighborhood environment, such as the number of intersections or the type of road network (e.g. grid or cul-de-sacs), whereas accessibility usually refers to the walking distance to the nearest public transport station or major town centers.

2.4.Overview of Land use - Transport models

There are principally three methods to predict the impacts of land use factors on transport and travel demand. The first is to ask people how they would change their location and mobility behavior if certain factors, such as land use regulations or transport costs, would change ('stated preference'). The second consists of drawing conclusions from observed decision behavior of people under different conditions on how they would be likely to behave if these factors would change ('revealed preference'). The third method is to simulate human decision behavior in mathematical models.

In the 1950s first efforts were made in the USA to study the interrelationship between transport and the spatial development of cities systematically. *Hansen, (1959)* demonstrated for Washington, DC that locations with good accessibility had a higher chance of being developed, and at a higher density, than remote locations ("How accessibility shapes land use").

The recognition that trip and location decisions co-determine each other and that therefore transport and land use planning needed to be co-ordinate, quickly spread among American planners, and the 'land-use transport feedback cycle' became a commonplace in the American planning literature. The set of relationships implied by this term can be briefly summarized as follows

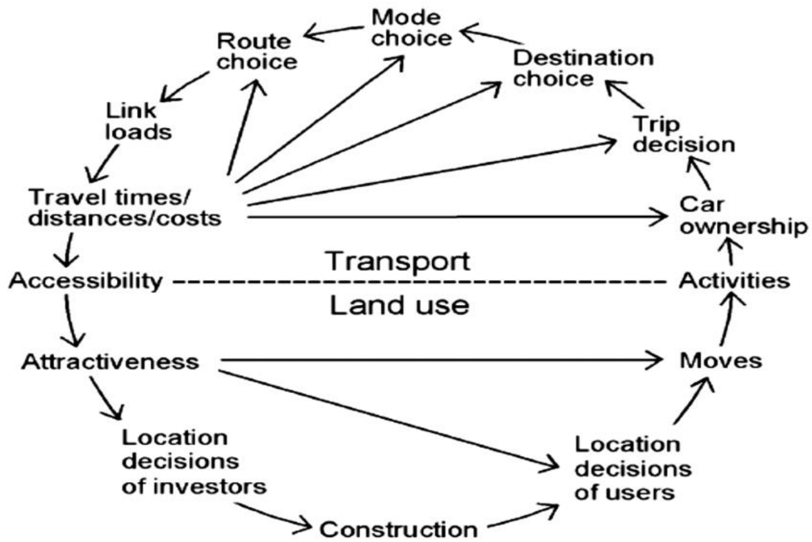

Figure.2.3. *The Land use Transport Feedback cycle*

- The distribution of land uses, such as residential, industrial or commercial, over the urban area determines the locations of human activities such as living, working, shopping, education or leisure.
- The distribution of human activities in space requires spatial interactions or trips in the transport system to overcome the distance between the locations of activities.
- The distribution of infrastructure in the transport system creates opportunities for spatial interactions and can be measured as accessibility.
- The distribution of accessibility in space co-determines location decisions and so results in changes of the land use system.

For this overview, the following contemporary urban land-use transport models are selected for comparative review. These models represent the current state of the art of urban modeling, though it cannot be excluded that promising new approaches in this rapidly moving field are overlooked.

TLUMIP the land-use transport model of the US State of Oregon developed in the Oregon Transport and Land Use Model Integration Program (ODOT, 2002);

TRANUS the transport and land-use model developed by de la Barra (de la Barra, 1982; de la Barra et al. 1984; de la Barra 1989, 1998);

MUSSA the '5-Stage Land-Use Transport Model' developed for Santiago de Chile by Martinez (1991, 1992a,1992b; Martinez and Donoso, 1995; Martinez, 1996, 1997a, 1997b);

LILT the Leeds Integrated Land-Use/Transport model developed at the University of Leeds by Mackett (1983, 1990c, 1991a, 1991b);

MEPLAN the integrated modelling package developed by Marcial Echenique & Partners (Echenique et al., 1969; Echenique and Williams, 1980; Echenique, 1985; Echenique et al., 1990; Hunt and Echenique, 1993; Hunt and Simmonds, 1993, Williams 1994; Hunt 1994);

METROSIM the microeconomic land-use and transport model developed for the New York Metropolitan Area by Anas (1992, 1994, 1998);

DELTA the land-use/economic modelling package by Davids Simmonds Consultancy, Cambridge, UK (Simmonds and Still, 1998; Simmonds, 2001);

ILUTE the Integrated Land Use, Transportation, Environment modelling system under development at several Canadian universities (Miller and Salvini, 2001);

IMREL the Integrated Model of Residential and Employment Location developed at the Royal Institute of Technology, Stockholm by Anderstig and Mattsson (1991, 1998);

Literatures compare these models in terms of the criteria comprehensiveness, model structure, theoretical foundations, modeling techniques, dynamics, data requirements, calibration and validation, operationally and applicability. It has been stated that all the models address only two of the above criteria.

Chapter Three

Research Methodology

3.1. Introduction

This chapter of the paper introduces the research design and research approach. The types of data required, sources of data, collection mechanisms and the data analysis method used for this specific study will also be briefly discussed in this section of the paper. The study area and selected site will also be described in this chapter.

3.2. Study Area

This research/Study is conducted on the western part of Addis Ababa, specifically, the Asko (Mickey Leland Condominium site) – Merkato/Autobus Tera – Piassa (Arada) – Paulos/ Medhanialem corridor. The reason/Rationale behind choosing this part of the city and particularly, the corridor under reference is the conveniences to establish Traffic Analysis Zones (TAZ) that have potential to represent the identified problem at hand. The arrangement of the section is also convenient to have different types of TAZs in line with the research question. The non probabilistic sampling method was used.

The basic characteristics of the study area, in terms of the nature of public transport demand and supply, land use type and mix, population density, location (as measured distance from an accepted urban center, or transfer zones) have been discussed as follows.

Land Use Mix

From the defined problem point of view, the selected corridor has different locations /areas with different land use types and mixes. This helped the researcher to develop potential TAZs representing each type of land use or different land use mix levels. The land use mix was determined by employing the entropy formula (Journal of Transportation and land use, Kevin Manaugh and Tyler Kreider, Mc Gill University, 2013). The entropy derived from the following equation indicates the diversity of land use in a TAZ.

Entropy = $-\sum_{i=1}^{n} \ln p_i \ * [\ln p_i \ / \ln n]$

Where; P_i = Proportion of Land use type i in a TAZ.

n = Total number of Land use types within the TAZ.

Entropy of zero represents extremely homogenous land use, whereas entropy of one indicates the land use is equally heterogeneous across all land use types. The dataset includes four land use types including administrative and parkland, commercial, residential, and recreational.

Population Density

Depending on the population density, the study area, particularly the selected corridor has variable population density in line with their type of land use and distribution of activities encountered with the locations/ areas along the corridor.

Population density for each TAZ was calculated as ratio of total population of the TAZ to the total area of the TAZ. The population for each analysis zone was projected from the population of the woreda in which the TAZ is located, by the following relationship;

$$\frac{P_w}{P_{TAZ}} = \frac{A_w}{A_{TAZ}}$$

$$P_{TAZ} = \frac{P_w}{A_w} * A_{TAZ}$$

Where, P_w & P_{TAZ} are the population of the woreda and TAZ respectively.

And A_w and A_{TAZ} , are area of the woreda and the TAZ respectively.

Generally, the study area and corridor was identified and selected so that the nature and magnitude of the defined problem is better explained and shown. The corridor has been rated as good in that it can relate the problem to the identified factors believed to have effect on the problem.

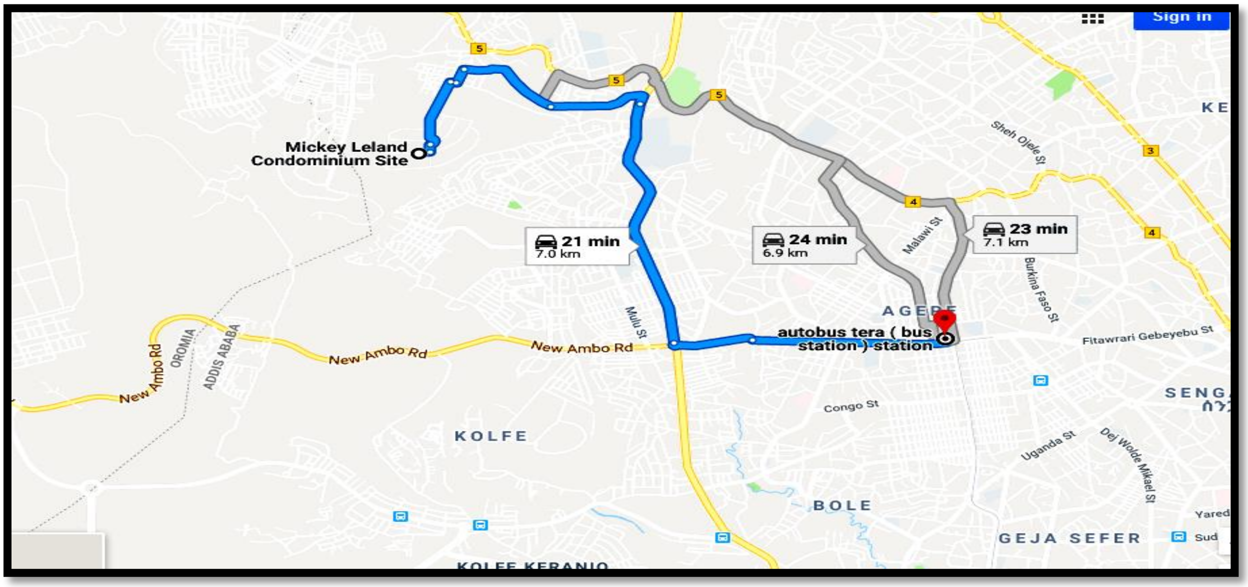

Figure 3.1 The two Routes from Mickey Leland Condominium site –to Merkato/Autobus Tera

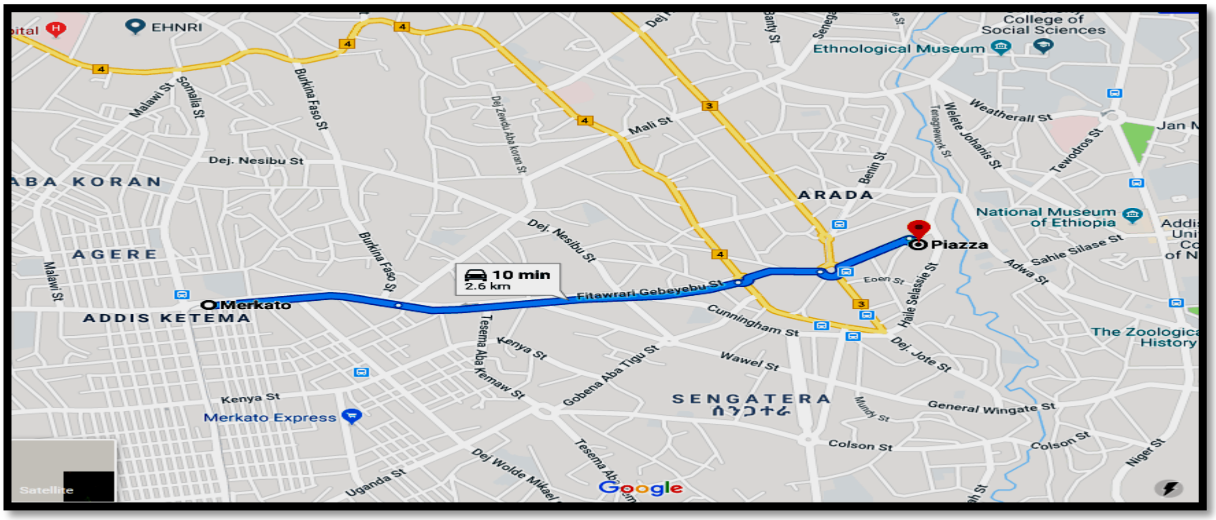

Figure 3.2. Merkato – to – Piassa/Arada Route

Figure 3.3. Mickey Leland Condomium site - to – Piassa/Arada Route

3.3 Research Design and Approach

Conditions were arranged for TAZ development, data collection and data analysis in such a way that the research questions are better seen and become relevant to the research purpose. As such, to achieve the general and specific objective of the research, that are set and defined in the general back ground section of the paper, descriptive research design has been used.

Both Qualitative and Quantitative data have been used for this study. The independent factors (Land use mix, Population Density, Centeredness) were more of qualitative and were collected from the secondary data sources. The dependent variable (demand and Change in demand over space and time) were collected by direct survey and from numerical observations.

Data collection spots were selected and identified based on the research question and the analysis method to be applied. The study has three independent variables (factors) with two levels each. With this eight possible combinations were identified. Following this the locations which have a potential to represent the combinations are selected as count station. As such the following table has been developed to better explain the nature of the study area. As Zone - to - Zone demands are the main concern of the study, intermediate stops were ignored.

Table 3.1. Count Stations with their respective characteristics

		Land Use Mix (Index)			
		0		**1**	
Centeredness		**Center (C)**	**Not Center(NC)**	**Center(C)**	**Not Center (NC)**
Density	**High (H)**		Asko		Paulos/Med
	Low (L)		Merkato	Piassa	

3.4. Survey Objectives

In order to determine the effects of the identified factors on the dependent variable, direct measurement of demand for public transport (field survey) deemed necessary. The main objectives of the survey are;

- To determine the demand to and from each developed TAZs
- To examine the change in demand for public transport to/from the TAZs at different times of day.
- To test if there is a significant difference in public transport demand to and from a given TAZ with specific land use characteristics over time.
- To examine if the land use nature, population density and centeredness have effects on the variation change in demand to and from a given TAZ with time and

3.5. Establishment of the Traffic Analysis Zones

The establishment of the Traffic analysis zones for this study is related to the hypothesis of the study and the research question. The data collection sites and data analysis method have had also impacts on the formulation of the TAZs As such the following were the main factors to delineate the TAZs.

Land Use Mix

Land use mix, as a factor has been scaled to have two levels for this specific study. This was made by approximating the mix levels above 0.5 to 1, and that of less than 0.5 to 0. This is because of;

- ✓ The way the activities are distributed within the study area and the prevailing land use mix.
- ✓ Ease of analysis. To switch with the requirements of factorial ANOVA.
- ✓ Scarcity of data.

Accordingly, mix level of **1** and **0** were determined. Implying perfect mix (heterogeneity) and poor mix (only a single type of land use). As such Piassa/Arada and Paulos /Medhanialem have been indentified to have a land use mix level of **1** and those of Merakto and Mickey Leland had a mix level of **0**, as only one type of activity was dominantly there.

Population Density

The Average population of each TAZ was calculated using the previous relationship. Then, Population density was determined by taking the ratio of population the area. Depending on the values, again two levels of population density have been identified, as **High (H)** and **Low (L)**. This was made for the ease of analysis and convenience.

As such Asko (Mickey Leland condominium site) and Paulos/Medhanialem were identified to have high population density and Piassa/Arada and Merkato/Autobus Tera were set to have low population density.

Centeredness

The centeredness of each locations of the study area was measured from the Arada/Piassa. For this specific study, two levels of centeredness have been identified. These were **Center(C)** and **Not Center (NC).** With respect to this variable, all the TAZs except piassa its self were set to have a centeredness level of **"NC",** while that of Piassa was **"C"**

In line with the nature of land use and characteristics of the transport demand and supply of the study area, four distinct traffic analysis zones have been established for this study. The detailed information for each TAZ has been summarized as follows;

TAZ1, commercial activities dominantly take place and serves as a beginning and termination for public transport vehicles, Located at a certain distance from center.

Figure 3.4 *Merkato / Autobus Tera*

TAZ 2, an isolated condominium site with river and roads as natural and man-made boundaries, purely serving for Residential purposes. Located at sub urban /peripheral part of the city, highly populated

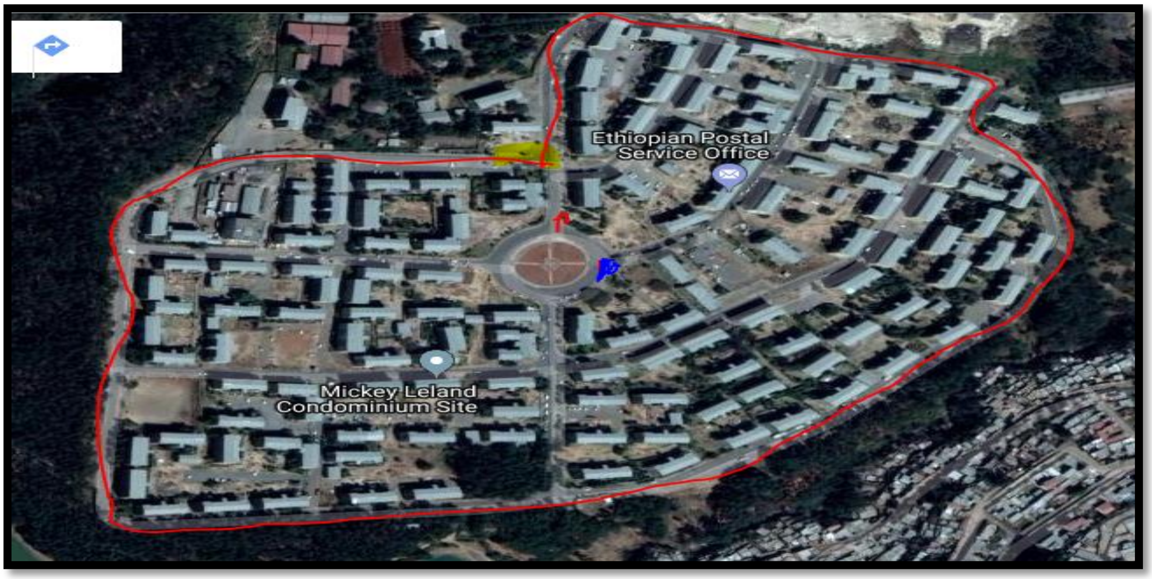

Figure 3.5 *Mickey Leland Condominium Site*

TAZ 3 (Mixed land use, away from center, high population density)

TAZ 4 A transfer zone, with nearly perfect land use mixes, a center

Figure 3.6 Piassa/Arada

Table 3.2. *Summary of the variables (factors) with the TAZs*

Explanatory Variable	TAZ 1	TAZ 2	TAZ 3	TAZ4
Land Use Mix Index	0.23	0.149	0.414	0.56
Population Density(/km^2)	3318.2	7438.4	5649.21	2394.42
Centeredness (Km from the center)	2.6	9.4	4.4	0

.

3.6. Data Requirements and survey Instruments

Two set of data types were used for this specific study, the primary data and the secondary data. The only primary data, that has been used for this study was the public transport demand to and from each traffic analysis zones, in terms of passenger volume and load. These data were collected by direct counting of the number of passengers arriving (alighting) or leaving (boarding) the counting stations for every 15minutes of the counting period.

The counting activities were conducted by manual means and at some of the stations video recordings were also employed to avoid the effects of high demand.

The counts were made for five different days of a week, three weeks days (Monday, Wednesday, Friday) and the weekends. The week days were selected (chosen) to represent and assess the effects of commuter trips, while those of weekends were to represent the non commuter ones. The time of count were decided to represent the nominal peak hours. As such, 7:00 AM to 9:00AM for the morning session and 5:30PM to 7:30PM for the afternoon session were chosen. This makes the survey inclusive and comprehensive as it was possible to include the effects Market/Non market days, morning /afternoon and commuter/non commuter trips.

The counting stations were determined/identified and selected based on the centroids of the developed (established) TAZs and analysis method. As such, Taxi, Bus, higer stations and terminals were chosen to be the counting stations of each TAZ. The Piassa/Arada taxi/bus/higer terminals, Autobus tera, Merkato taxi and bus stations, Medhanialem roundabout, Mickeyly land Condominium site and birchiko junctions were the counting stations of the study area.

The secondary data include the population and population density of the TAZs, activity distributions in each TAZ, the separation distance between each TAZ. These data were the major inputs for the TAZ demarcation and development process.

3.7. Data Analysis Method

After the direct measured demands between two TAZ were converted to “changed in demand” and presented, simple statistical descriptions have been made and discussed. Following that ANOVA was employed to conduct factorial analysis to test the significance and interaction of the factors.

Chapter Four

Research Results and Discussion

4.1.Introduction

The raw data, semi processed data and the analyzed data results will be presented and discussed in this chapter**.** All the data that are presented in this section were for both morning and afternoon sessions. The raw data include the direct measured volume of passengers and the semi processed data is the volume that is converted into the change in demand between the two O- D pairs. Analysis results are the out puts of SPSS, partial factorial ANOVA analysis.

4.2.Results and Discussions

As it can be seen from the following table significant differences in public transport demand have been observed between O – D pairs or TAZs at different days of a week and times of a day. These differences in demand over time, and the change in the direction of the demands were raised from;

- The basic nature of home based trip productions and attractions.
- The characteristics of the TAZs
- Trip purposes and journey times

Table 4.1 Daily direct demands to /from each TAZ

FROM		MERKATO			PIASSA/ARADA			ASKO (MICKLYLAND COND.			PAULOS/MED.		
TO		PIASSA/ARADA	ASKO (MICKLYLAND COND.	PAULOS/MED.	ASKO (MICKLY.COND.	PAULOS/MED.	MERKATO	PAULOS/MED.	PIASSA/ARADA	MERKATO	MERKATO	PIASSA/ARADA	ASKO(MICKYL.COND.
DAY 1	G	1514	27	16	43	12	811	1290	2591	1500	1011	990	26
	N	891	1345	674	1849	841	909	69	188	42	57	74	430

DAY 2	G	1240	23	24	36	42	1891	1535	2624	2493	1422	1106	47
	AFTERNOON	1704	2101	781	2399	1492	1794	54	207	129	206	89	867
DAY 3	G	867	44	21	48	29	1290	1401	2498	1492	189	1241	24
	AFTERNOON	627	1308	651	2192	1291	1351	31	41	87	62	69	907
DAY 4	G	1298	181	28	40	34	1677	1621	2461	2341	1211	1192	34
	N	1540	1944	812	2236	1354	1701	86	149	44	59	73	841
DAY5	G	640	28	31	33	12	982	841	1981	1194	741	701	28
	AFTERNOON	357	2008	694	2440	1190	749	27	87	31	26	38	909

Complying with the research question, the other important data was the change in public transport demand between the established TAZs. These data were presented as follows for the morning and afternoon sessions separately.

Table 4.2 Change in Demand between the pair of TAZs (***Afternoon session***)

I.No.		Day 1 Demand	Day 1 Change in Demand	Day 2 Demand	Day 2 Change in Demand	Day 3 Demand	Day 3 Change in Demand	Day 4 Demand	Day 4 Change in Demand	Day 5 Demand	Day 5 Change in Demand
	P - M	909		1794		1351		1701		749	
1	M - P	891	18	1704	90	1112	239	1540	161	357	392
	P - A	1849		2399		2192		2236		2440	
2	A - P	188	1661	207	2192	141	2051	149	2087	187	2253
	M - A	1344		2101		1308		1944		2008	
3	A - M	42	1302	129	1972	87	1221	64	1880	749	1259
	A - PM	69		54		31		86		27	
4	PM - A	730	661	867	813	907	876	841	755	909	882
	M - PM	674		781		650		810		694	
5	PM - M	57	617	206	575	62	588	59	751	26	668
	PM - P	74		89		69		73		38	
6	P - PM	1125	1051	1492	1403	1291	1222	1354	1281	1190	1152

Table 4.3 Change in Demand between the pair of TAZs (***Morning session***)

I.No.		Day 1 Demand	Day 1 Change in Demand	Day 2 Demand	Day 2 Change in Demand	Day 3 Demand	Day 3 Change in Demand	Day 4 Demand	Day 4 Change in Demand	Day 5 Demand	Day 5 Change in Demand
	P - M	811		1891		1290		1677		982	
1	M - P	1514	703	1240	651	867	423	1298	379	640	342
	P - A	43		36		48		40		33	
2	A - P	2591	2548	2624	2588	2498	2450	2461	2421	1981	1948
	M - A	27		23		44		181		28	
3	A - M	1500	1473	2493	2470	1492	1448	2341	2160	1194	1166
	A - PM	1290		1235		1101		1221		841	
4	PM - A	26	1264	47	1188	24	1077	34	1187	28	813
	M - PM	16		24		21		28		31	
5	PM - M	1011	995	1422	1398	989	968	1211	1183	741	710
	PM - P	990		1106		1241		1192		701	
6	P - PM	12	978	42	1064	29	1212	31	1161	21	680

The statistical summary of the above table is summarized once again by the following table

Table 4.4 *Statistical summary of Afternoon observations*

Statistical Parameter	**P – M M – P (1)**	**P – A A – P (2)**	**M – A A – M (3)**	**A – PM PM – A (4)**	**M – PM PM – M (5)**	**P – PM PM – P (6)**
Mean	180	2048.8	1526.8	797.4	639.8	1221.8
Median	161	2087	1302	813	617	1222
Standard Deviation	144.16	231.33	366.98	92.17	71.69	132.65
Range	374	592	751	221	176	352
Minimum	18	1661	1221	661	575	1051
Maximum	392	2253	1972	882	751	1403

Table 4.5 *Statistical summary of Morning observations*

Statistical Parameter	**P – M M – P (1)**	**P – A A – P (2)**	**M – A A – M (3)**	**A – PM PM – A (4)**	**M – PM PM – M (5)**	**P – PM PM – P (6)**
Mean	499.6	2391	1742.2	1105.2	1050.8	1019
Median	423	2450	1473	1187	995	1064
Standard Deviation	165.486	256.947	548.23	176.0659	256.972	209.78
Range	361	640	1310	448	688	532
Minimum	342	1948	1160	813	710	680
Maximum	703	2588	2470	1261	1398	1212

To better show the difference in "change in demand" between the O – D pairs, the following histograms have been plotted in terms of average change in demand.

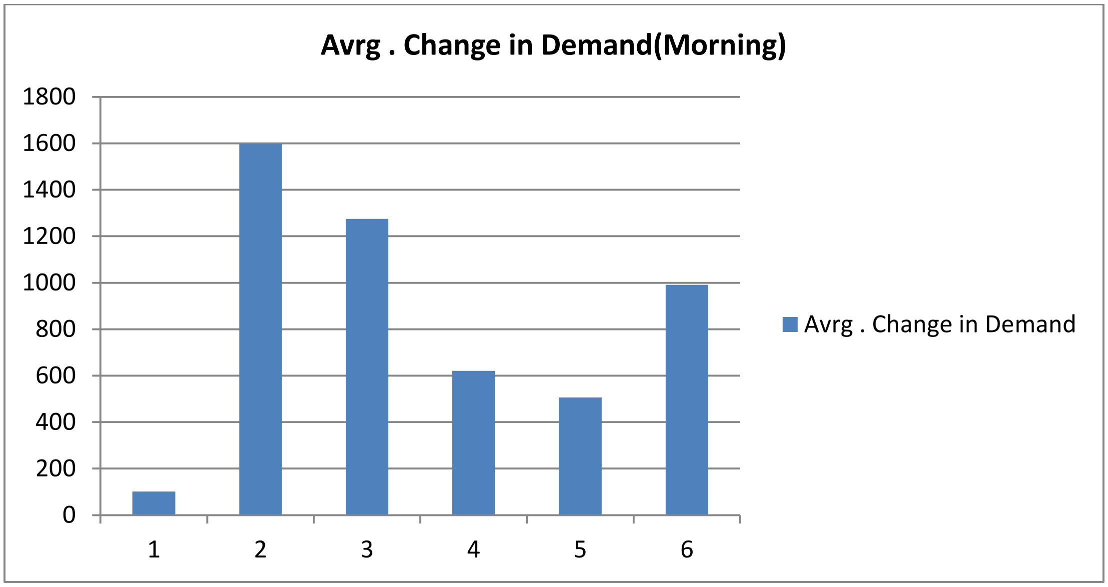

Figure 4.1. Average change in demand between the O – D Pairs (**morning**)

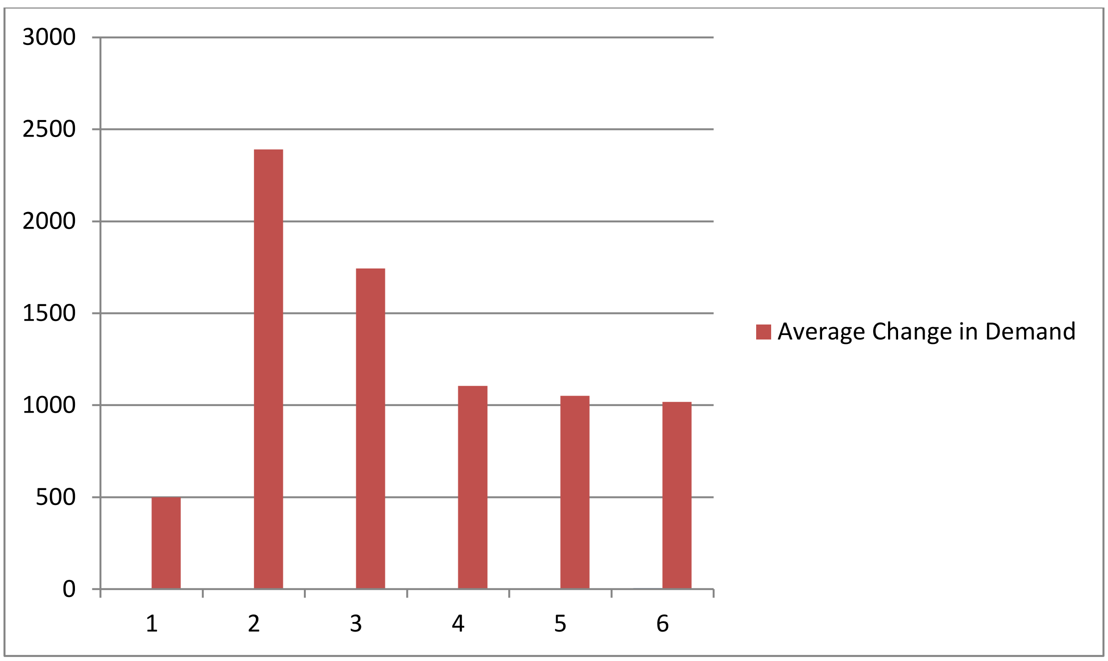

Figure 4.2. Average change in demand between the OS – D Pairs **(Afternoon**)

Discussion

- Relatively higher change in demand have been observed between M – A & A – M and P – A & A – P O-D pairs. This shows that change in demand is higher between TAZs with land use mix index of 0 and 1, (Piassa – Asko). Higher change in demand has also been observed between TAZs with similar land use mix index, but different dominant activity or land use type (Merkato - Asko). This basically because of the limitations that the mix index doesn't differentiate the land use type. That means a perfect mix of industrial and park might score identical to the same proportion of residential and commercial. This condition has already been set as one of the limitations of the independent zonal factor of the study, land use mix index.

- The raw data shows that the trip production and attraction capacity of each TAZ. For Example, 1514trips were counted from Merkato – Piassa in the morning session of the first day, while only 27 trips were counted from Merkato – Mickley land condominium site during the same session. This shows that the condominium site has less attraction capacity at this particular time of day.
- Non center TAZs with higher population density and poor land use mix, generates more trips in the morning, and these trips would be attracted to the center, less populated and better mixed TAZs.
- As it has been hypothesized, densely populated TAZs generate higher demand than less populated TAZs. This means dominantly residential TAZs generate higher demand, while commercial and transfer zones attract nearly the same amount of trip at the same time of day. But as the commercial and transfer centers do not have trips to generate in the morning sessions, the trips to be produced in these TAZs and attracted to the purely residential centers would be significantly lesser. For example, Mickeyleland cond. Site generated 2591and 1500 trips to Piassa and Merkato respectively in the morning session of the first survey day, while only 43 and 27 trips are generated from Piassa and merkato respectively to Mickeyleland cond. during the same day and time. This is why it has become culture to see lines of people waiting for public transport at Asko, to Piassa and merkato , in the morning,and at at Piassa and Merkato to Asko in theafternoon. This is indeed can be related to the supply side as well.
- Statistical presented mean values could prove that higher change in demand has been observed between TAZs which is almost purely residential and that of commercial and transfer zones.
- Significant differences in change in demand have been observed between TAZs with different population density (Piassa – Asko) and (Piassa – Merkato).

- Considerable differences in change in demand have been observed between TAZs with different centeredness (Merkato – Asko) and (Piassa _ Merkato).
- Generally, the demand to and from a TAZ, during a specified time of day, depends on the mix level, population density and centeredness of the TAZs. A TAZ with poor Land use mix (Residential) generates higher demand during the morning session and receives lesser demand in the same session.

SPSS was employed to conduct ANOVA, particularly; partial factorial analysis to examine the interaction between the dependent variable and zonal independent variables. As the result the following tables were generated.

Descriptive Statistics (*Morning*)

	Mean	Std. Deviation	Analysis N
Population Density	.50	.504	60
Centeredness	.25	.437	60
land Use Mix	.50	.504	60
Change Demand	1301.73	668.280	60

Correlation Matrix

		Population Density	Centeredness	Land Use Mix	Change in Demand
Correlation	Population Density	1.000	-.577	.48	0.52
	Centeredness	-.577	1.000	.577	-.62
	Land Use Mix	.000	.577	1.000	-0.82
	Change in Demand	.52	-.62	-.82	1.000
Sig. (1-tailed)	Population Density		.000	.500	-.423
	Centeredness	.000		.000	.495
	Land Use Mix	.500	.000		-.82
	Change in Demand	-.423	.495	-.82	

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.585
Bartlett's Test of Sphericity	Approx. Chi-Square	73.031

df	6
Sig.	.000

Total Variance Explained

Factor	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	1.850	46.239	46.239	1.638	40.943	40.943	1.282	32.038	32.038
2	1.021	25.517	71.756	.795	19.880	60.822	1.151	28.784	60.822
3	.980	24.507	96.263						
4	.149	3.737	100.000						

Extraction Method: Principal Axis Factoring.

Communalities

	Initial	Extraction
Population Density	.563	.771
Centeredness	.707	.802
Land Use Mix	.570	.842
Change in Demand	.370	.218

Extraction Method: Principal Axis Factoring.

Factor Matrix[a]

	Factor	
	1	2
Population Density	-.613	.629
Centeredness	.895	-.42
Land Use Mix	.667	.630
Change in Demand	-.32	-.24

Extraction Method: Principal Axis Factoring.

Rotated Factor Matrix[a]

	Factor	
	1	2
Population Density	-.057	.876
Centeredness	.652	-.614
Land Use Mix	.916	.045
Change in Demand	-.416	.670

Extraction Method: Principal Axis Factoring.

Rotation Method: Varimax with Kaiser Normalization.

Descriptive Statistics (Afternoon)

	Mean	Std. Deviation	Analysis N
Land Use Mix	.50	.504	60
Population Density	.50	.504	60
Centeredness	.25	.437	60
Change in Demand	1068.98	641.920	60

Correlation Matrix

		Land Use Mix	Population Density	Centeredness	Change in Demand
Correlation	Land Use Mix	1.000	-.580	.577	-.800
	Population Density	-.580	1.000	-.577	.362
	Centeredness	.577	-.577	1.000	-.703
	Change in Demand	-.800	.362	-.703	1.000

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.579
Bartlett's Test of Sphericity	Approx. Chi-Square	72.927
	df	6
	Sig.	.000

Communalities

	Initial
land type	.554
population	.572
centeredness	.714
change demand	.469

Total Variance Explained

Factor	Initial Eigenvalues			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	1.822	45.562	45.562	1.343	33.573	33.573
2	1.073	26.823	72.385	1.064	26.609	60.182
3	.956	23.910	96.295			
4	.148	3.705	100.000			

Rotated Factor Matrix[a]

	Factor	
	1	2
Land Use Mix	.760	.154
Population Density	-.198	.918
Centeredness	.852	-.432
Change in Demand	.011	.104

Extraction Method: Principal Axis Factoring.

Rotation Method: Varimax with Kaiser Normalization.

Discussion

A. Correlation coefficient

- In both cases, $0.5< r < 1$, so strong negative correlation has been observed between land use mix and change in demand centeredness and change in demand. This implies that change in demand is inversely related with land use mix, or change in demand decreases as land use mix increases. Lower change in demand would occur between TAZs with better land use mix level.
- In both cases, $0.5< r < 1$, so strong negative correlation has been observed between centeredness and change in demand. Change in demand is inversely related with centeredness, or change in demand decreases as centeredness increases. Lower change in demand would be expected between two TAZs of same/similar centeredness.
- In both cases, $0.3< r < 0.5$, so moderate positive correlation has been observed between population density and change in demand. Change in demand is directly related with population density.

B. Kaiser-Meyer-Olkin Measure of Sampling Adequacy.

- As the values are > 0.5 in both cases it can be said that there were sufficient items (variables) for each factor. The factors considered here for this analysis are land use mix level (0, 1), centeredness (C, NC) and population density (L, H). The KMO values found for both case (morning and afternoon sessions) are greater than 0.5. This implies the level of treatments for each factor was sufficient for the analysis.
- Again the significance level are 0, this shows that the factors (Variables) are highly correlated. The significance level shows that the factors are highly correlated. Regardless of the direction (+ve, -ve), all the factors, the dependent and the independent ones are highly correlated.

Chapter Five

Conclusion and Recommendations

5.1. Conclusions

Based on the data and analysis results of this study, the following conclusions can be made.

- Relatively higher change in demand have been observed between M – A & A – M and P – A & A – P O-D pairs. This shows that change in demand is higher between TAZs with land use mix index of 0 and 1, (Piassa – Asko). Higher change in demand has also been observed between TAZs with similar land use mix index, but different dominant activity or land use type (Merkato - Asko). This basically because of the limitations that the mix index doesn't differentiate the land use type. That means a perfect mix of industrial and park might score identical to the same proportion of residential and commercial. This condition has already been set as one of the limitations of the independent zonal factor of the study, land use mix index.
- Generally, it can be concluded that balanced demand can be attained between TAZs with similar land use types, mix indexes. Which means relatively lesser change in demand would be observed between two or more TAZs with such land use characteristics.
- Significant differences in change in demand have been observed between TAZs with different population density (Piassa – Asko) and (Piassa – Merkato).
- Considerable differences in change in demand have been observed between TAZs with different centeredness (Merkato – Asko) and (Piassa _ Merkato).
- Direction of demand varies with time of day and the zonal characteristics of the TAZs.
- Un balanced demand to and from some TAZs over time.
- Strong negative correlation has been observed between land use mix and change in demand centeredness and change in demand.
- Strong negative correlation has been observed between centeredness and change in demand.
- Moderate positive correlation has been observed between population density and change in demand.
- Statistical tests (KMO), has proved that it can be said that there were sufficient items (variables) for each factor.

5.2.Recommendations

Relying on the results of the study and discussions made above the researcher forwards the following recommendations.

- Promotion of perfect land use mix in urban planning practices and policies.
  This involves insertion of all the possible or target activities or land use types into the area to be planned. Either or both of the horizontal and vertical mixing can be used as a method.
- Re-planning of the city through an extensive land-use readjustment, fundamental re-organization of infrastructure networks as well as revitalizing run down urban basics.

By promoting the perfect/ better land use mix, or heterogeneous distribution of activities, it can be clearly known that we would have a balanced population density here and there and can also bring about shift in the urban center (down town) . With this we would expect very less change in demand to and from a zone in such arrangements and developments. This will in turn comes with the following changes.

  - Reduction of the need to travel
  - Modal shift
  - Balanced demand to and from TAZs within the city (Lesser change in demand)

With the above listed changes at hand, the following social, environmental and economic benefits would be harvested. These are;

- Lesser investment on transport developments.
  This happens whenever we have lesser need to travel and there is a modal shift from the Motorized vehicles to the non motorized one.
- Better Utilization of Roads.
- Lesser gas emission.
  If there is less number of vehicles on roads, we expect lesser emission
- Better service quality (LOS) on the urban streets.
  Related with the directional split and number of vehicles on each direction

- Lesser congestion, accident and delay.

  This is also a function of directional split and the number of vehicles on each direction
- Better Attraction of investors on the transport services.

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