LEVEL OF SMART TRANSPORTATION SYSTEM APPLICATION IN ADDIS ABABA, THE CASE OF MEGENAGNA NODE

By

Aziza Ahmed Galib

A Master's Thesis Submitted to the Department of Architecture

School of Civil Engineering and Architecture

Presented in Partial Fulfilment of the Requirement for the Degree of Master's in Urban Planning and Design

Office of Graduate Studies

Adama Science and Technology University

June 2023

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APPROVAL OF BOARD OF EXAMINERS

I, the advisor of the thesis entitled **"Level of smart transportation system application in Addis Ababa, the case of Megenagna node"** and developed by **Aziza Ahmed** hereby certify that the recommendation and suggestions made by the board of examiners are appropriately incorporated into the final version of the thesis.

Advisor	Signature	Date

We, the undersigned, members of the Board of Examiners of the thesis by **Aziza Ahmed** have read and evaluated the thesis entitled **"Level of smart transportation system application in Addis Ababa, the case of Megenagna node"** and examined the candidate during the open defense. This is, therefore, to certify that the thesis is accepted for partial fulfillment of the requirement of the degree of Master of Science in **Urban planning**.

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Finally, approval and acceptance of the thesis is contingent upon submission of its final copy to the Office of Postgraduate Studies (OPGS) through the Department Graduate Council (DGC) and School Graduate Committee (SGC).

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DECLARATION

I hereby declare that this Master Thesis entitled **"Level of smart transportation system application in Addis Ababa, the case of Megenagna node"** is my original work. That is, it has not been submitted for the award of any academic degree, diploma or certificate in any other university. All sources of materials that are used for this thesis have been duly acknowledged through citation.

Aziza Ahmed	_____	_____
Name of the student	Signature	Date

RECOMMENDATION

I, the advisor of this thesis, hereby certify that I/we have read the revised version of the thesis entitled **"Level of smart transportation system application in Addis Ababa, the case of Megenagna node"** prepared under my/our guidance by **Aziza Ahmed** submitted in partial fulfillment of the requirements for the degree of Mater's of Science in **Urban planning and design** Therefore, I recommend the submission of revised version of the thesis to the department following the applicable procedures.

Daniel Lirebo (Phd)	_____	_____
Major Advisor	Signature	Date

ADVISOR APPROVAL SHEET

To: Architecture Department

Subject: Thesis Submission

This is to certify that the thesis entitled **"Level of smart transportation system application in Addis Ababa, the case of Megenagna node"** submitted in partial fulfillment of the requirements for the degree of Master's in **"Urban Planning and Design"**, the Graduate Program of the Department of Architecture, and has been carried out by **Aziza Ahmed** Id. No **PGR/12909/12**, under my supervision. Therefore, I recommend that the student has fulfilled the requirements and hence hereby he can submit the thesis to the department.

Daniel Lirebo (Phd)	_____	_____
Name of Major Advisor	Signature	Date

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"The best teachers are those who show you where to look, but don't tell you what to see"

Alexandra K. Trenfor

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ACRONYMS

AA	Addis Ababa
AACRA	Addis Ababa City Road Authority
AATMA	Addis Ababa Traffic Management Agency
AI	Artificial Intelligence
ATMS	Advanced transportation management system
CBD	Central Business District
CCTV	Closed Circuit Television
CS	Collector Street
GDP	Growth Domestic Production
ICT	Information Communication Technology
IoT	Internet of Things
IT'S	Information Technology System
ITS	Intellegent Transport System
LS	Local Street
PAS	Principal Arterial streets
PT	Public Transport
QOS	Quality Of Service
SCT	Smart City Transportation
SP	Structural Plan
SAS	Sub-Arterial Streets
TOD	Transite Oriented Development
UN	United Nations

ABSTRACT

For decade transportation has been consider as a link to all aspects of life worldwide. In this case the world's natural environment, social well-being, and economic development usually depends on transportation system. Managing the increasing traffic is still a big challenge in Addis Ababa, Megenagna node. Smart transportation system applications provide solution to these problems with the help of new technologies that can achieve the desired transportation balances and for the system to be efficient. The Addis Ababa Traffic Management Agency tries to implement different smart transportation system application in the offices to manage the road congestion. Measuring the challenges and effectiveness of those management practices in the area is the focus of this research. And the route from Megenagna, Arat kilo to kotebe is selected as the case study. Observations like congestion pattern direct field measurements and find different application on the street and secondary data were the main sources for the analysis. Therefore, a wide range of descriptions about smart transportation system are discussed and the study is aimed to focus on what level of smart transportation system application is applied in the study area. Because the transport facilities and this nodal point do not meet with the demand of the people. Therefore, seek to investigate different tools that need smart transportation for Megenagna, diaspora nodal space to clarify the extravagance of energy regarding to transport management. It deeply analyzed the case study are using quantitative and qualitative data collected from observation, questioner, and application of measurements, and collected reports from different institutions. Then those data analyzed through different system concepts. In this part, different software is applied including GIS, Excel, CAD, and Revit. Then analyzed data is presented by maps, tables, and figures. Those analyses led to certain findings which show the nodal is not satisfactory to people and needs an intervention. To solve the existing problems and to come up with smart transport, there search provides design recommendation to create a sustainable transportation system by supporting of information technology.

Key terms: Level, Node, Accessibility, Smart Transportation, Information Technology System

CHAPTER ONE: INTRODUCTION

Transport has a major impact on the spatial and economic development of cities and regions, the quantity and quality of transport infrastructure influence the attractiveness and desirability of urban centers (Turner et al., 1998). All transactions require communications and most require transport of goods or people to work, shopping, tourist sites, meeting locations. Thus, it is fair to say that transportation is central to economic activity (Encarta, G, 2009). Most metropolitan areas in the world are experiencing transport problems during commuting hours and this can be resolved by infrastructure expansions (Lynch, 1999). However, new roads or widening existing ones require more land, and expansion costs are high. Moreover, such solutions may not be feasible in metropolitan areas because of lack of space or harmful effects on the environment (Dumitru et al., 2016).

As modernization and consequently urbanization moves forward, the use of motorized transport to maintain the socio-economic and physical integration of the city increases. Addis Ababa city transport authority report depicts, the vehicle fleet in 2018/19 is estimated to be 524,444 with the average growth of the vehicle increase 30 percent in the year. By 2050, 70% of the population will be living in the urban areas and transport problems in metropolitan areas will be high such as lack of space and congestion as well as poor air quality increase. Smart transport, therefore, becomes a necessity to reduce traffic congestion, increase productivity, and reduce carbon emissions (Margulis, 2003). In the west, different countries are using smart transportation systems. For individuals, it saves money and provides them with choices, freedom, and opportunities (Darido, 2008).

When a city experiences rapid population growth, it will exert pressure on the existing economic, social, and environmental structure so developing countries should have better practice smart transportation to reduces city resources and energy (Margulis, 2003). Smart transportation system is an established route to resolve and minimize traffic problems, ITS encompasses all modes of transportation which is necessary to evaluate, develop, analyze, and integrates new sensors and concept to achieves traffic efficiency, conserve time and enhances safety and comfort for drivers, pedestrian and other groups (Peter and Christian, 1998).

1.1 Motivation of the study

The motivation of the study was because of the following basic reasons: the first was an observation, this nodal space has poor road infrastructure, coupled with inadequate and inefficient transport activities, transport movement is chaotic and unreliable because of the high number of population and vehicles that cause high traffic congestion, secondly, the transportation system has given less attention of management by government and using poor technology.

1.2 Background of the study

Transportation problems in urban areas continue to increase as a consequence of both higher mobility and increasing car ownership of people. On the other hand, the supply of transport infrastructure and facilities remains practically unchanged due to the high cost of land acquisition and construction of new roads (Castells, 1999). Urban mobility, which is increasingly becoming inefficient in Megenagna and resulting overcrowded, can be viewed as a function of various components of the urban transport system problems. Addis Ababa road and transport bureau are established with a mission to ensure the city to have modern, secured, fast, and reliable transportation services which fulfill the city transportation desire and movement proportionally with a fair price (Haile. M, 2005) But Megenagna nodal spaces of the transportation system has problems with lack of integration between the planning and management. Hence to identify this area of transport challenges, to indicate a clear direction, and identify measures to be taken to optimally utilize the positive experience and to take the necessary measure to solve the complex problem in this area, the study will explore different national transport policy and strategies. As Junks (2004) states that different cities transport engineers and practitioners had concluded that transport problems can be mastered only through the introduction of appropriate smart transportation system application which change travel behavior to increase the transportation system efficiency and also to achieve a reduction level of fuel conservation and road cost while focusing on the safety and accessibility.

To support urban activities, the creation of smart transportation is preferable. Smart transportation is an urban vision that fosters citizens' engagement and technological integration

of the city's infrastructure and it introduces new practices services that highly impact policy-making and planning, while it co-exists with urban facilities (Darido, 2008).

The objective of building smart transportation system is to improve the quality of life by using technology and improving sustainability by using of an information system that collects data about traffic, vehicles, and usage of a different mode of transportation (Alan Black, 2005). Applications of information and communications technology in the transport sector have led to the development of so-called "intelligent transport systems" (ITS), which can improve traffic efficiency and safety, with positive outcomes for sustainable development (Roger. Y, 2005). The study area is located in Addis Ababa which is the name of Megenagna, diaspora nodal spaces and this area is known by transportation activities. Even if there is a different mode of transport in the site but with lack of transport infrastructures and transport management. So, it needs to analyze the existing situation to develop a different smart transport application which is more benefit for sustainable transport Statement of Problems.

1.3 Statement of problems

Urbanization is increasing, which means the population has exceeded, and there will be high movement in the urban center so cities have to concern about the future generation regarding to transportation system especially different sectors should have considered creating easily accessible for the people. Now a day Addis Ababa especially Megenagna nodal spaces has been affected by a high-density population with several vehicles that makes it congestion. The area is activated for transportation system but with the lack of transport infrastructures and traffic management applications.

Figure 1.1: Congestion in the study area

In Megenagna nodal spaces, the major problem of road traffic flow that has been occurring is due to high density, unsustainable design, and condition of the road, increased vehicle density, over speeding, rash, and bad crossing behaviour of pedestrians, violation of the rules and regulations, unfitting condition of the vehicles.

The economic benefits of transportation in this place are higher than other areas. However, its lack of proper integration between traffic management and flow of people's movement. The number of vehicles especially public transport in Megenagna is rising in reaction to the increasing in demand. However, the facilities quality for passenger services remains in poor transport user for an instant for vehicles there is not sufficient space and good access for movement.

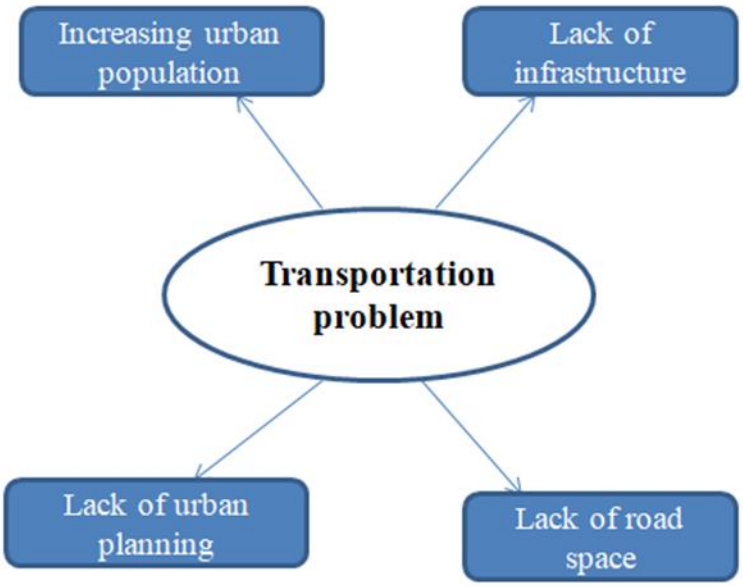

Figure 1.2: Causes of transportation problem in Megenagna node

The area of traffic management system still there is reflected as there is few speeds control system recording mechanism on repeated traffic rules offenders because many drivers violate traffic rules and regulation which in turn leads to increased traffic accident and congestion. These critical traffic-related problems require a radical solution to facilitate the traffic movement and resolve daily jams; usually caused by regularly increasing number of vehicles, competing

for space that doesn't easily expand to cater for an increased number of daily travellers that do not help much in reducing the size and Frequency of the problem.

In this area congestion was affected by many sectors in different ways either directly or indirectly and imposes a cost The problem of this congestion was losing productivity from more time spent traveling rather than working and missing meetings. As a result, those are associating with costs including lost time, increasing vehicle operating cost.

1.4 Research Objectives

General Objective

To measure the level of smart transportation system applications at Megenagna diaspora node, Addis Ababa, Ethiopia.

Specific objectives are to;

1. Assess the existing condition of transportation system in the study area.
2. To identify the main cause of congestion in the study area.
3. To find out various smart transport application that have been adapted by transport management.
4. To examine the integration between transportation policy and information technology system.

1.5 Research question

The main question is how to measure the level of smart transportation application in the study area? The specific questions are:

1. What is the existing condition of the transportation system in the study area?
2. What are the main causes to occur the congestion?
3. What kinds of smart transport application are being used in the transport management.
4. How to examine the integration between the transportation policy and ITS?

1.6 Significance of the Researches

The significance of the study is unquestionable, the transport system problem and congestion now a day a big issue in Megenagna is relatively a place that has a high rate of traffic flow and overcrowded as compared to other remaining places. This research is going to have the following significance. Firstly, to determine how transportation planning process is currently taking place and to get the attitudes, knowledge about the existing level of congestion. Secondly, the study may serve as an input in transport safety policy planning and implementation to helping to promote safety awareness activities leading to encourage growth.

1.7 Scope of The Study

The study had employed in Megenagna, diaspora node, and the road is led to Arat kilo to Kotebe. Thematically the study had focused on the level of smart transportation system application in case of Megenagna nodal spaces by investigating the main challenges of the transportation system. Spatially the study had assessed the road led to Arat kilo and Kotebe (2.1km length and 36m width) main road with uneven sidewalk width (ranging from 4-2m) on both sides of direction.

1.8 Limitation of the study

An adequate and reliable information is important to undertake any kind of study. However, the unwillingness and carelessness of some respondents while filling in the questionnaires during data collection.

1.9 Organization of the study

The study paper is organized in a way that current chapter, chapter one deals with the introduction of the study, the subsequent chapter two presents the review of the related literature, chapter three presents the methodology, chapter four deals with the data analysis and results of the findings and the last chapter five deals with the summary, conclusion and recommendation parts of the study in reference.

CHAPTER TWO: LITERATURE REVIEW

2.1 Theoretical review

2.1.1 Transportation system

An urban transportation system consists of all elements of transportation, including infrastructure and traffic flows, in a city as a functioning entity. Urban transport plays an important role in transferring people and goods from a given origin to some other destination (within a city or beyond). In a context of rapid urbanization, a well-planned transport system is essential for attracting investment. The presence of efficient transport system makes a city liveable and productive; Streets link spaces for different land uses and are vital for urban transport services. It is alsocentral to economic activity and to people's lives, it enables them to engage in work, attend school, shop for food and other goods, and participate in all of the activities that comprise human existence (William J. Mitchell 2007).

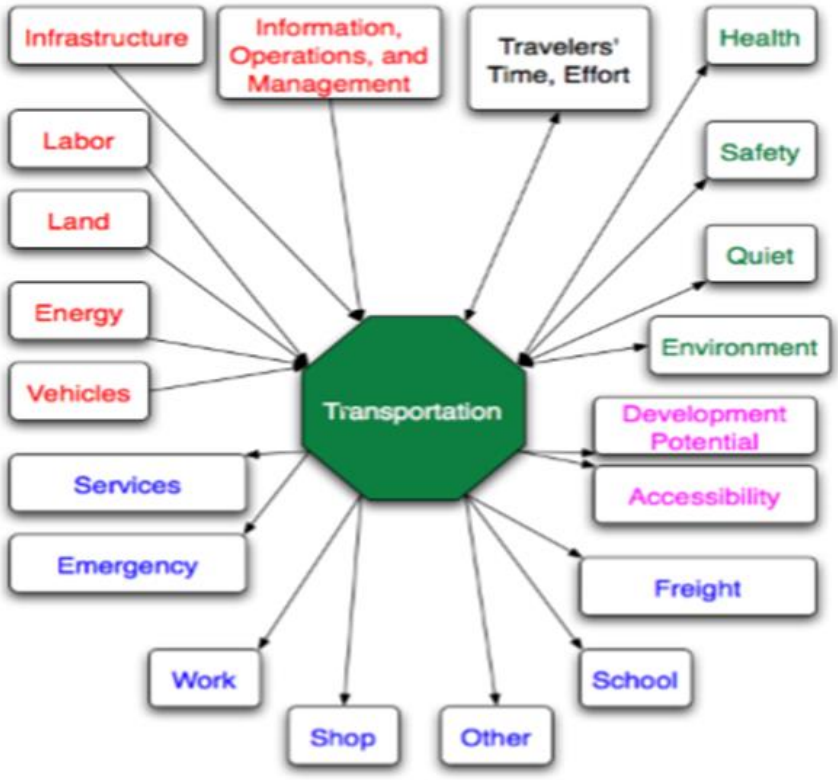

Figure 2.1: Transportation inputs and outputs

Transportation systems form integral building blocks for a modern society to satisfy people needs and demand by improving transport infrastructure (Ramachandran and Devi 2011) suggest that efficient and safe movement of people and goods ensures a thriving economy and provides for an improved quality of life.

Figure 2.2: Good transportation system approaches

2.1.2 Smart Transportation system

Smart Transport System becomes better transportation safety and versatility and open up global connectivity by means of productivity improvements extract through the group action of advanced publicity technologies into the moving support and intelligent vehicle (Ganesh and Ramesh 2010). Moreover, Improved safety, higher productivity and efficiency, more environmental friendliness and better life quality are the four major purposes of smart transportation that make it less traffic accident, less commute time, better passenger experience will lead us to a wonderful transportation (Ganesh and Ramesh 2010).

Smart transport is the most decisive cornerstone for a city's development and prosperity, revolutionizing transport transforms the concept of the city. Urban structure and transport system developments are closely connected as evidenced by theories like the urban land rent

theory and location theory, which conceptualize the connection between transport and urban land use (Ganesh and Ramesh 2010).

And actual intelligent Transportation system (ITs) are envisioned to relief the broad spectrum of contests that affect our current traffic infrastructures suggested that to adjust the traffic and passenger movements and to improve system management, unified real-time information on the traffic condition in the urban area use one or combination of various ICTs that have been used in traffic regulating around the world (Young, 2014).

Smart transportation is about….

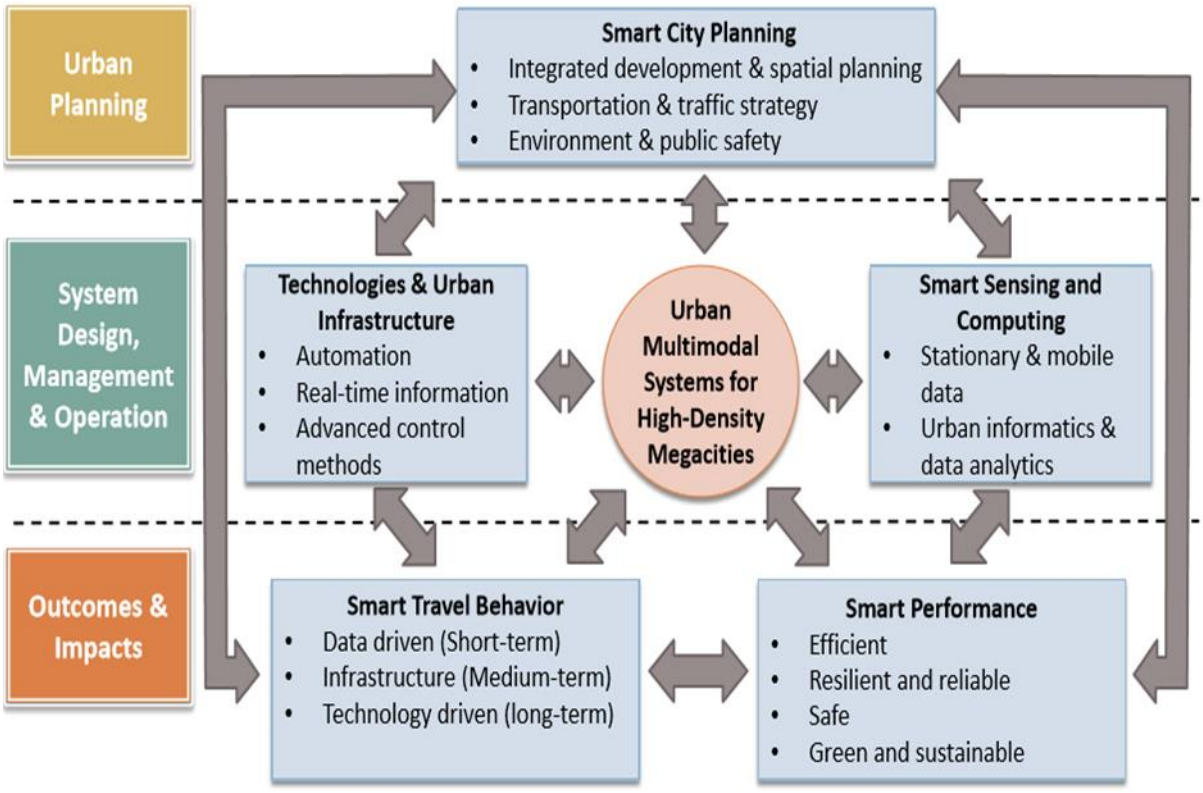

Figure 2.3: Smart transportation as multimodal system

The most obvious benefits and goals of smart transport are social sustainability and increased efficiency of the transportation network. Smart parking can help sustain the city's mobility, and its importance is the ability to balance the sustainability and the quality of transportation. One of the measures to be taken in intelligent transport management is the use of sensor communication to manage it through advanced solutions, which the most important parameters

to be answered: delay, fuel consumption, etc (Bhupendra Singh, 2014). Another significant point about traffic and traffic accidents, in addition to other topics or areas, is human mistakes, which are the cause of many traffic problems and accidents, such as the wrong car park. Apart from providing proper infrastructure, intelligent parking and in general intelligence, the various parts of the city's mobility can reduce the risks of common mistakes and indiscretions (Bentley l. et al. 2005).

2.1.3 Information Technology System (ITS) related to Transportation

Information technology system (ITS) are applications of advanced communications, navigation and information processing technologies that are designed to improve the performance of the existing transport system, specifically by improving safety, efficiency, comfort and reducing adverse environmental effects. ITS applications include advanced traffic management systems, advanced travel information systems, electronic payment systems, and advanced vehicle control systems, advanced commercial vehicle operations and advanced public transport systems (Ruhlandt, 2018).

According to the definition of the Ministry of Transport, Construction and Maritime Economy (2013), smart transportation system divided into two generation's application.

A. Road safety application exploit wireless communications between surrounding ITS abstraction to slow down traffic accidents and to secure the drivers from various road risk. To that end, each ITS entity regularly broadcasts safety messages to report its neighborhood about its situation and location information. Furthermore, depending on specific events (e.g., accidents, see road risk), each ITS entity may also generate the transmission of notification messages to close-by vehicles and emergency services.

B. Traffic Management Applications represent a second major class of ITS applications, whose main objective is to enhance the management and coordination of traffic flows and to provide various cooperative navigation services to the drivers. These applications rely on the collection and analysis of the exchanged ITS messages. This application can transfer all traffic data to transport offices that can make it the system too simple and get solution for any congestion and will reduces traffic accidents. Smart transportation according to World Bank named "ITS for Developing Countries" addresses the condition of ITS and discusses the long-term, society-wide

benefits that ITS can provide and ways that ITS can provide more immediate benefits to individuals by helping to make surface transportation more affordable, more reliable, and more efficient (Singh and Gupta, 2014).

This ITS is useful to Improved mobility for people and freight, including greater access to transportation for the elderly, the disabled, and people living in remote locations, Greater compatibility of surface transportation with the environment and Fewer traffic-related deaths (William J. Mitchell 2007).

2.2 Theories of smart transportation system

2.2.1 Optimal Control Theory in Smart Transportation

Optimal control theory deals with the problem of finding a control law for a given system such that a certain optimality criterion is achieved. It's widely used in engineering, information systems and management science to solve various types of management (Eboli and Mazzulla, 2012). It's important to gain more insights on reducing traffic congestion by using OCT because congestion reduction is essential to ITS. Optimal control theory is a fundamental enabler of such techniques there are five methods in smart transportation to mitigate traffic congestion problems, they are dynamic pricing, ramp metering, variable speed limits, traffic light control and the combination of different methods, namely the integrated control approach. sense, because on one hand the phenomenon of traffic congestion on highways is indeed quite serious in many places, on the other hand highways, freeways and motorways are relatively easier to model than regular roads in urban areas (Eboli and Mazzulla, 2012).

ITS can be roughly grouped within three broad categories those are: Advanced Traveler Information Systems; Advanced Transportation Management Systems; IT'S-Enabled Transportation Pricing Systems and Advanced Public Transportation Systems (Benevolo Dameri and D'Auria, 2016). In real-time traffic information including optimal routes, navigations, traffic congestion predictions, accident warnings, etc. to support the drivers to make better driving decisions. Advanced Transportation Management Systems involve traffic control devices to resolve traffic issues, such as traffic signals, ramp meters, variable message signs, and traffic operations centres. ITS-Enabled Transportation Pricing Systems mainly focus on the optimal congestion pricing (Azkuna I, 2005).

Advanced Public Transportation Systems allow trains and buses to report their positioning information to the passengers so passengers can be informed of their real-time arrival or departure information. Finally, Fully Integrated Intelligent Transportation systems include vehicle-to-infrastructure and vehicle-to-vehicle integration which enable assets to communication with each other in the transportation systems (Robert. Y, 2012).

ITS contributes to all major transport policy objectives set by a nation. Many ITS applications are aimed at either optimizing the available supply of road infrastructure or reducing demand for it (Sandira. L, 2007).

Data collection: ITS is capable of capturing a range of roadway information from the number of vehicles passing a certain point. ITS can track the position of vehicles through, say, mobile phone or satellite.

Data transfer, processing and analysis: ITS can communicate the data to central units. There, the data is aggregated and transformed into information used to determine future actions.

Informed decision-making: The processed data can be applied in a number of ways to ensure the efficient operation of road networks. For e.g., a road operator may use ITS data for highway management; or a road user may alter his route from updated traffic data.

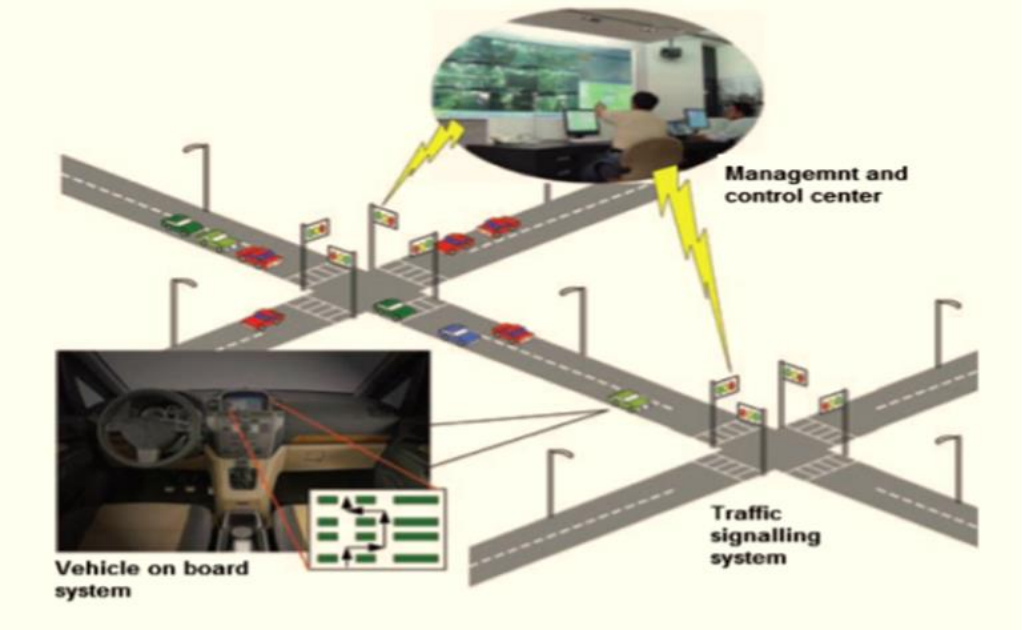

Figure 2.4: Traffic management system

2.2.2 Smart Transportation Planning

Smart transport plan aims to create a sustainable urban transport system by addressing different objectives: Ensure the accessibility offered by the transport system is available to all, improve safety and security, reduce air and noise pollution, greenhouse gas emissions and energy consumption, Improve the efficiency and cost-effectiveness of the transportation of persons and goods, contribute to enhancing the attractiveness and quality of the urban environment and urban design. From the user perspective the whole transport network is one entity with trips not stopping at historically defined city or administrative boundaries (Maslow, 2000).

Urban ITS implementation has to plan beyond municipal borders and can thus be recognized as major enabler for sustainable mobility in metropolitan areas. Maslow state that the development of new information communication technologies, enabling simulation, real-time control, systems integration and data exchange, offers the opportunity to address complex problems such as urban congestion at their metropolitan scale (Finamos, 2007).

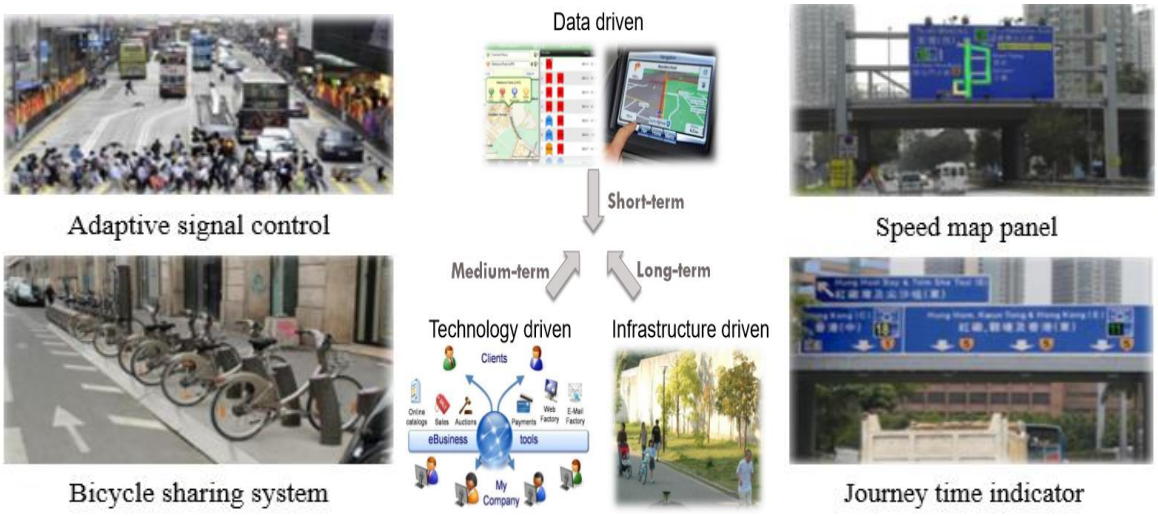

Figure 2.5: Smart transport planning feature

The best transportation solution that fits within the context, is affordable, is supported by the communities, and can be implemented in a reasonable proper planning and time frame. transportation system management is an important alternative such as new or widened roadways. If safety and not congestion is the problem, consider focused solutions that can improve safety without increasing capacity so that must be considered on all transport.

2.2.3 Smart Transportation System related to urban planning

The issue of transportation system is featured over a dozen times in the text of the New Urban Agenda, as a key to limit urban sprawl, support balanced urban and metropolitan development, reduce the social and environmental costs of congestion and pollution (Peirce et al., 2006-8, Buchoud, 2008). Now a day smart transportation system can solve a variety of urban problems that road traffic traces through the exchange of information between peoples and vehicles. An effective urban policy aligned with intelligent transport solutions helps avoid irregular spatial development, provide a social and economic integration of different urban areas and population groups, and avoid environmental degradation. In developing countries smart transportation system is promoting to reduces the traffic congestion and urban planning policies have different implication about this term because accessibility and connectivity is one of the urban smart growth principles and smart transportation system supports urban activities and new urbanism by using different technologies (Ashondah,2010).

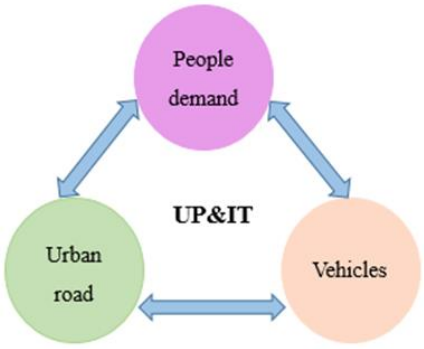

Figure 2.6: Relationship of urban planning and IT

The quality of life of the urban population “Planning Cities for People” (Takaaki, 2009). When put in perspective, accessibility can be regarded in different ways: physical accessibility, temporal accessibility, affordability, equal accessibility for certain categories of users (pedestrians, persons with reduced mobility), accessibility of urban areas and services (including transport-related ones), etc. The effective alignment between smart transport and urban planning, results-orientation, formulating "Cities for People" strategies and (political, financial, legal, communication, marketing) tools to implement them has a pivotal part to play in ensuring accessibility. In general, the integration between smart transportation and urban planning can achieve effective solution for transport problems.

2.2.4 Transit Oriented Development

Transit-oriented development is describing as development in an existing or planned transit community that adds to the walkable, vibrant, mixed-use environment and is oriented towards frequent, high-quality transit service that connects the community to the rest of the city and A desirable feature of TOD is street orientation, as demonstrated in a number of recent studies (Encarta, 2009). A TOD complex is typically cantered on a transit station with gradually decreasing density contour lines, characterized by high density development in the center with progressively lower density development spreading outward from the center (Kennedy, 2010)

The major benefits of TOD can be : Reduced traffic congestion, traffic hazards, and environmental pollution, Increased transit ridership due to the 4D attributes of TOD: density, diversity, design and distance to station, Potential for significant economic development in proximity to TOD, Reduced household spending on transportation, with a focus on lower-income households, Reduced dependence on non-renewable energy, Promoting of walkable communities and desirable land uses, Potential reduction of urban sprawl and Promoting of vibrant station centres, conducive to pedestrian travel (Peter Freeman & Christian Jamen 1998).

2.2.5 Sustainable Transportation Systems Development

The development of a sustainable transportation system starts with the organization of urban space to reduce the demand for transportation by reducing the number of trips and the length of travel distance (Jinand Kite, 2009). The organization of urban space helps in reducing the distances between places and people and as a result people travel less to obtain goods and services. Reducing the transportation demand reduces the use of scarce resources and produces less adverse impact on the environment, social and economy (Bertsimas, 2002). A sustainable transportation system also requires the provision of a diverse, integrated and balanced public transportation services. The transportation needs of different groups are different due to the distances they need to travel, their trip purpose, income, age, gender, physical ability etc. A sustainable urban transport system should adequately deal with negative external and internal factors while serving its primary function i.e., providing mobility, including for disadvantaged and vulnerable groups which constitutes an integral component of the Millennium Development Goals (Bertsimas, 2002).

2.2.6 Smart transportation standards in roadway types

The transportation context consists of the role that the roadway plays, or is anticipated to play within the local community and the larger region. It also refers to the supporting street network, and the interaction of the roadway with that network (Kolosz et al, 2008). Main Street although not one of the Smart Transportation roadway categories, the concept of Main Street has an important place in Smart Transportation.

Table 2.1: Road way categories

Roadway class	Roadway type	Desired operating Speed(mph)	Average trip Length(ml	Volume	Intersection Spacing(ft.)	Comments
Arterial	Regional	30-55	15-35	10,000-40,000	660-1,320	Roadways in this category would be considered 'principal Arterial' in traditional functional classification
Arterial	Community	25-55	7-25	5,000-25,000	300-1,320	'Minor arterial' in traditional classification but may include road segment.
Collectors	Community	25-55	5-10	5,000-15,000	300-660	Often similar in appearances to a community arterial
Collector	Neighborhood	25-35	<7	<6,000	300-660	Similar in appearances to local roadways and considers as minor collectors.
Local	Local	20-30	<5	<5	200-600	

Sources from: Smart transportation guidebook, Marion. T (2012)

Table 2.2: Signal Spacing

Road types	Urban Context	Suburban Context	Rural Context
Regional Arterial	660 to 1320 ft.	1320 to 1540 ft.	1980 ft.
Community Arterial	300ft to 1100ft.	1320 ft.	1540 ft.
Community Collector	300 to 660 ft.	660 to 1320 ft.	1540 ft.

Sources from: Smart transportation guidebook, Marion. T (2012)

Smart roundabout

Smart roundabout, a channelized intersection with one-way traffic flow around a central island, can be used as an alternative to signalized intersections that help to maintain traffic flow, while improving safety through reducing vehicular speeds and the number of vehicle conflict points (Fujise, M, 2009). For many communities, the deciding factors in using a roundabout are the traffic calming effect provided by the horizontal deflection.

Figure 2.7: Smart roundabout

Table 2.3: Characteristics of roundabout categories

Design Element	Mini Roundabout	Urban Compact	Urban Single-Lane	Urban Double-Lane	Rural Single-Lane	Rural Double-Lane
Maximum entry design speed	15mph	15mph	20mph	25mph	25mph	30mph
Typical inscribed circle diameter	45-80ft.	80-100ft.	100-130ft.	150-180ft.	115-130ft.	180-200ft.
Typical daily services volume on 4-leg	10,000 veh/day	15,000 Veh/day	20,000 Veh/day	**	20,000 Veh/day	**

Sources from: Smart transportation guidebook, Marion. T (2012)

2.2.6.1 Smart transportation in public transport network

Network is a kind of graph, which is a geometric figure made up of points and lines. In practical applications, the points and lines are always interconnected. Each line has a point at each end, and several lines may meet at a single point. Transportation planners usually refer to a point as a node and to a line as a link. A network is defined as a graph in which there is some sort of flow (Alan Bleak 2005).

***Bus Network*:** In most cities, bus routes are radials converging on the CBD. In medium-size and large cities, the bus networks are larger and more complex and may not resemble any simple pattern. Most routes follow major streets, so the network resembles the street pattern (Alan Bleak 2005). There may be irregular streets, topographical constraints, or barriers such as freeways and railroad tracks. Further, routes are adjusted according to demand. In low-density areas where most households have automobiles, routes are spaced farther apart than in high-density areas that generate more transit riders. Socioeconomic characteristics of the residents also play a part.

Low-income communities may be served by numerous routes, while wealthy areas have little service.

Designing a Single Route: Bus routes should follow arterial streets as much as possible and avoid minor streets. Arterial streets are wide enough for buses which are otherwise difficult to maneuver and have higher average speeds because of traffic engineering measures designed to increase flow. Side streets are more likely to be blocked by parked vehicles or children playing. Arterials are more likely to be lined with buildings that have high trip generation. Ideally a bus route should be straight and direct. This is easier for people to understand, and usually it provides a faster trip from end to end (Alan Bleak 2005).

***Spacing of Stops*:** The spacing of stops largely determines the average operating speed on a line, which affects the quality of service perceived by travelers. The maximum speed of the vehicles is only secondary. In deciding on the number of stops on a line, it is important to realize that each stop causes time losses for braking to a stop, unloading and loading passengers, and accelerating back to running speed. There is a certain spacing of stops that will minimize travel time for passengers. As stops come closer together, each person walks less distance to a stop.

2.2.6.2 Smart transportation in pedestrian facilities

Walkability is a critical gauge of a healthy community. Whether in an urban core or a suburban area, pedestrian activity is best accommodated by a connected network of sidewalks, complementary land uses, attractive streets aping, regular controlled pedestrian crossings, and lower speeds of passing traffic (William J. Mitchell 2007).

***Sidewalks*:** are desirable to support both mobility and safety. The safety benefit was particularly pronounced in residential and mixed residential areas. Approximately 15% of pedestrian accidents in suburban and rural areas occur when a pedestrian is struck while walking along a roadway and the 13 ft (Banks J.H. 2002).

Sidewalk and Buffer Widths: provides recommended dimensions for “clear sidewalk widths,” or the section of sidewalk unencumbered by street furniture and not immediately next to buildings. The concept of clear sidewalk width is the same as “effective walkway width” and Clear sidewalk widths of 8 to 10 feet are recommended for major roadways in town center and urban core contexts (Banks J.H. 2002).

Crosswalks: should be present on all legs at signalized intersections, unless hazardous conditions make one or two legs unsuitable for installation and midblock crosswalks should typically not be installed within 300 feet of signalized intersections (Blokland, M. 2004).

Medians: on multi-lane roadways, medians can be among the most desirable features for pedestrians. Medians reduce the time required for pedestrians to cross; delays are up to 10 times longer for pedestrians crossing undivided multilane roadways than roadways with medians. Medians should always be considered when the cart way width exceeds 60 ft (Blokland, M. 2004).

Curb extension: are installed at both intersections and mid-block locations. A common width is 6 ft., or slightly less than the width of a parallel parking lane. Their use should be restricted to on street (Blokland, M. 2004).

2.2.7 Smart Transport Components

Artificial Intelligence (AI) refers to a machine's ability to simulate the human mind by interpreting data it receives from its environment, learning from them and using that learning to successfully complete tasks, even in the most unexpected and novel scenarios (Benevolo and D'Auria, 2016). Connected and Autonomous Vehicles is any vehicle that can understand its surroundings, move, navigate and behave responsibly without human input, and at the same time has connectivity functions enabling it to be proactive, cooperative, well-informed and coordinated (Bentley l. et al. 2005).

Internet of Things (IoT) is a connectivity paradigm that empowers objects of everyday life to hear, see, listen and interpret streams of big data and communicate with one another and with users through integrated cloud technologies, software, sensors and human–machine interfaces (Ramachandran and Devi 2011). And States that role of smart transport components in reducing traffic related problems through wise use of the road networks and resources.

Smart transportation is the systematic, well planned and elaborated activity which is implemented to control, direct the flow of traffic and protect road accident, manage accidents if they occurred and ensuring the transportation system and users safety. Roger.Y (2005) also mentioned the benefits of smart transportation such as reduction of traffic congestions, accidents and traffic jams.

2.2.8 Tools for Smart Transport Systems

According CIVITASII (2005-20013) states that to optimize traffic flow, reduce crime rate and congestion to improve system management, integrated real time information on the traffic situation in the city transport data should be collect by: CCTV (Closed Circuit Television), which means the application of video cameras transmitting data to a set of video display unit (ICT control room). CCTV utilized for observation that aids to identification of wrong deed or security linked indecencies in general public as it happens. CCTV cameras are used to screen and capture pictures of what occurs in particular zones progressively (Ruhlandt, 2018).

GPS (Geographical Positioning systems) can be used for tracing vehicles‟ over speeding, goods delivery and public transport vehicles to display the exact location, and are useful to automatically yield authorized electronic freight documents and reports, status messages, etc (Singh and Gupta, 2014). The growing necessity of the driving public for exact traffic information has urged the development of huge scale dedicated effective infrastructure methods to collect traffic data and traffic monitoring system founded on GPS enabled smartphone exploits the existing infrastructure of the communication network (Blokland, M. 2004).

Automatic Number Plate Recognition: Patel, Shah and Patel (2013) agreed that traffic control and vehicle owner identification helps to traffic monitoring activity. Beside these lines, it is unrealistic to repulse errant separate drivers on the grounds that the traffic workers won't have the capacity to recover vehicle amount from the moving vehicle in light of the velocity of the vehicle (Quarshie, 2014). In-Car Systems**:** Koper, Tylor and kudu (2005) said that the high impact technologies in traffic implementation include integrated files; geographic information systems (GIS) and Wireless Local Area Network systems: Wi-Fi System is a good example of WLAN. Automated systems, such as programmed traffic count sites (e.g., automatic number plate recognition systems, congestion monitoring loop detectors in the surface of the roads) Place pod sensors: a IoT enabled smart parking sensors for on street parking and off-street public and privates parking management that provides accurate vehicle detection in parking spaces and stable over temperature fluctuation, even in harsh environment. This sensor incorporating real time parking data from places pod smart parking sensor in to parking management strategy can help to reduces traffic congestion and carbon emission, foster economic development and improve urban mobility (KarlonI.T, 2009).

2.3 Smart Transportation Elements

2.3.1 Smart street lighting

Smart lighting networks are becoming the platform for a wide variety of smart city innovations and vision of the city lighting network as a smart city platform is the next frontier for street lighting (Dawson, c. 2002). Connecting street lights together in a computer-controlled network opens the door to a wide range of innovative capabilities that save energy and improve the performance of the lighting system but beyond those applications lie the broader possibilities for deploying non-lighting solutions on the lighting network, making it a ubiquitous platform for smart city applications (Beken, 2007).

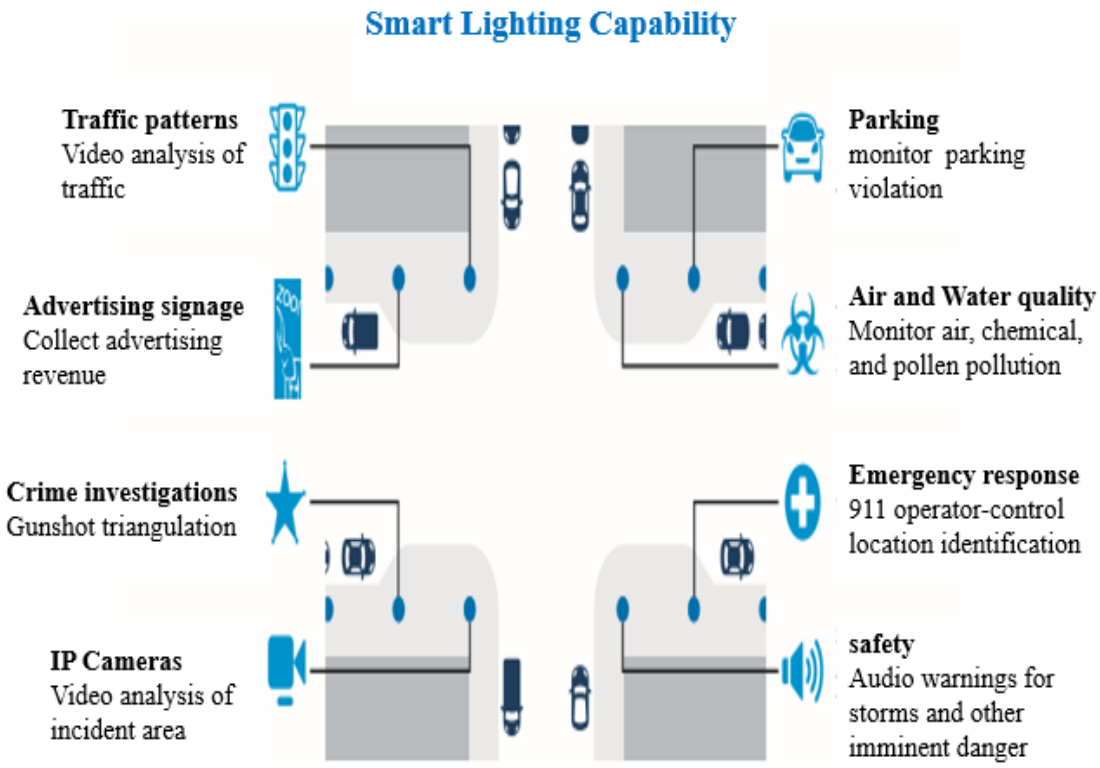

Figure 2.8: The capability of smart street lights

Lighting for the sidewalk and shop front area is most effectively provided by pedestrian-scale streetlights (12 to 16 ft. in height) placed inside the curb. Spaced about 60 ft. apart on ornamental poles, they can also provide roadway lighting for streets less than 45 ft. wide (Dawson, c. 2002). For lighting management, the main distinction is between basic and advanced lighting features.

2.3.2 Smart Parking Space

The parking lot consists of a group of parking spaces. The on-street parking can also be considered as a virtual parking lot. The state of a parking lot is the number of occupied spaces versus total spaces (Garrison W.L. and Ward J.D. 2001). Every parking lot has access to the Internet to communicate with the management system and users, and share parking information with other parking lots and in each parking lot, the reservation authority is deployed for authenticating the individual user's identity and reservation request. In this case, the reservation authority in the parking lot communicates with the specific user individually. It makes all pricing decisions regarding the state of parking lots and user demands this system is a closed-loop system to dynamically adjust parking price, balance the benefits between users, and service providers and reduce traffic searching for parking (Ranawana and Hewage, 2015).

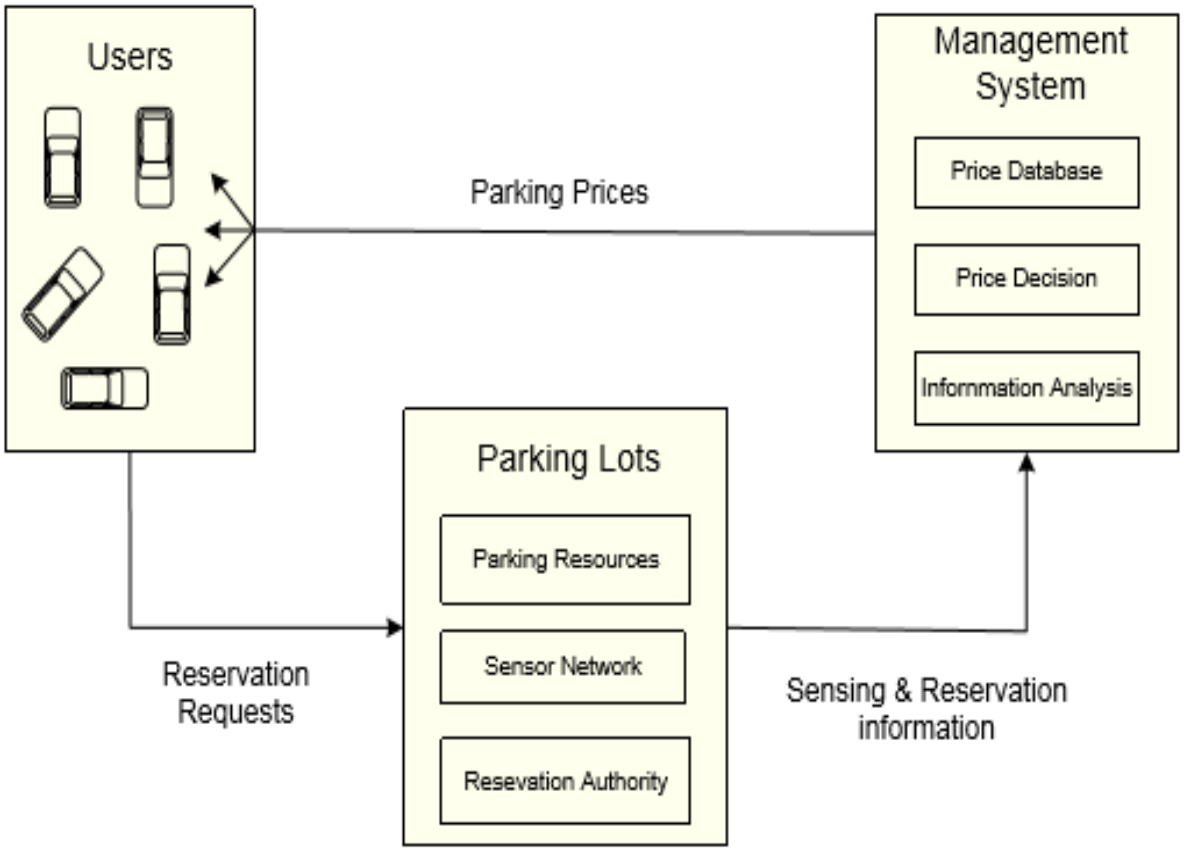

Figure 2.9: Integrated Smart Parking Management System

Parking should be provided on both sides of streets in commercial business districts, and on at least one side of residential areas (Suzuki, Cervero, Iuchi, 2013).

Table 2.4: Angled Parking Dimensions

Angle	Stall Length	Minimum width of Adjacent lane
45°	17ft., 8 in.	12 ft., 8 in.
50°	18 ft., 3 in.	13 ft., 3 in.
55°	18 ft., 8 in.	13 ft., 8 in.
60°	19 ft., 0 in.	14 ft., 6 in.
65°	19 ft., 2 in.	15 ft., 5 in.
70°	19 ft., 3 in.	16 ft., 6 in.
90°	18 ft., 0 in.	24 ft., 0 in.

Sources from: smart transportation guidebook, Marion. T (2012)

2.3.3 Smart Traffic Signage

Traffic signs are required in order to provide for the safe and orderly movement of motorized and non-motorized traffic. It also provides information on regulations which apply to specific locations or at specific times. Signs must have a carefully considered message, be of uniform design, distinctive shape and color, be applied and placed in a consistent manner (Verma et al, 2014).

Table 2.5: Clear sign distance requirements

Letter size(mm)	Minimum Sight Distances
490mm	380m
420mm	340m
350mm	300m
280mm	260m
210mm	220m
140mm	280m
112mm	160m

Sources from: smart transportation guidebook, Marion. T (2012)

2.3.4 Smart Road Marking

Road markings shall be used, to regulate traffic, warn or guide road-users. They may be used either alone or in conjunction with other signs or signals to emphasize or clarify their meaning. Road markings give you warnings or direction. If there is a yellow line to your left, there will be traffic coming towards you on the other side of that yellow line. Marking install in 75mm distance and 10degrees sample angle (Eboli and Mazzulla, 2012).

Figure 2.10: Road marking signs

2.3.5 Smart Transport Applications

2.3.5.1 Speeding Detection

Speeding is a major contributory factor to road accidents, and it increases both the risk of an accident occurring, and the severity of that accident. All EU countries are seeking to reduce the number of road accidents on their territory, as is the European Commission. Sweden has the most radical reduction target, with its "Vision Zero" Many others have quantified targets for reduction (Monet, 2013).

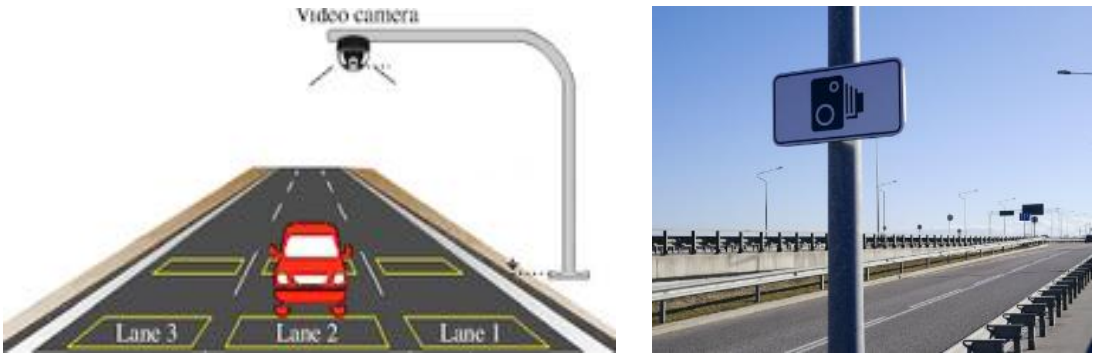

Figure 2.11: Smart speed detectors

2.3.5.2 Traffic Signal Control

Signal control systems can also be linked to real time information for drivers through variable message signs. ITS is used to manage linked and isolated traffic signal led junctions more efficiently, in relation to actual demand on the network in real-time. Inductive loop detectors in the pavement surface detect traffic levels, speeds and queue lengths and it communicate this to a local signal control computer (Gris Orange, 2010).

Figure 2.12: smart traffic signal

2.3.5.3 Ramp Control

Ramp control is used at peak periods to regulate the flow of traffic along a slip road (ramp) onto a motorway or other grade-separated road. Sensors on the main road detect traffic density and then the optimum level and spacing of joining traffic is calculated, and its access onto the main road regulated by traffic lights (Gris Orange, 2012).

2.4 Role of smart transportation system on economic dimension

In developed countries, smart transportation plays an important role in economic development is already a well-connected transport infrastructure network of a high quality, further investment in that infrastructure will on its own result in economic growth (Krambeck, 2008). These new transport-related technologies and economic helps the poverty reduction process in all aspects while stimulating economic development by creating different opportunities for the people, empowering the poor and enhancing safety/security. The links between smart transport and the economy is too huge, with transport investment having to meet multiple objectives: these may include improvements in safety, travel conditions, accessibility, environment, integration and

social inclusion (Eboli and Mazzulla, 2012). Thus, an increased proportion of investment may be allocated for infrastructure and other schemes that address multiple objectives rather than solely to maximise contributions to economic development (Darido, 2008). Generally, the use of smart transportation system in the economic development is saves city workers' time and money as data can be collected and analyzed automatically in a real-time manner. Traffic congestion growth negatively affects income employment growth so that creating of smart transportation system can solve this problem and benefits of economic development for the city (Krambeck, 2008).

2.5 Smart transportation policy

Smart transportation policy involves the use of advanced computer, electronic, and communications technologies to increase the safety and effectiveness of surface transportation system (Margulis, 2003). It encourages the use of ITS technologies to enhance the productivity of the existing infrastructure and vehicles that carry passengers, goods and services (i.e., highways, streets, bridges mass transit vehicles, and tracks).

Some examples of transportation systems supported by ITS technologies including advanced traffic signals; automated bus and maintenance vehicle location systems and those technologies should be improved the environment protection and energy use in addition, improving access of business to markets and the various factors of production and bringing about a more equitable allocation of road space with people, rather than vehicles, as its main policy (Bujina, 2006).Adding such technologies to the transportation systems saves lives, time and money and this policy require that all federally funded projects be guided by a regional ITS architecture and employ a system engineering process on a scale commensurate with the development (Margulis, 2003).

2.6 Smart Transport System Applications in Addis Ababa Status

The mass production and affordability of vehicles resulted in a new era of modern life and as a consequence and perpetual reciprocation paved ways for modern town planning for efficient multifaceted services; construction of standardized road network infrastructure; use of essential

standards traffic rues and sign; all for the safe. Cost effective and smooth utilization of the vehicular transportation system (Tizazu,2009).

In Addis Ababa transportation system is very challenging because of increasing the utilization of vehicular transport system with less infrastructure. Now a day this transportation system has improved to manage traffic flow and some element of the conventional system include traffic signalling lights, roadside, and on the road sign and weigh in station. When the number of vehicle and pedestrian using the existing road network is very low, the essence of traffic signalling or outnumbers the required road network, then congestion would be prevalent. This distracts the mobility of vehicles and pedestrians.

According to Addis Ababa Transport Authority (2010), this city has to experience to practices the smart transport applications in using mobility traffic control and monitoring system can be described.

- ✓ Some traffic signals are erected at critical road junctions.
- ✓ An attempt was tired on using GPS assisted navigation and guidance system built in to vehicles in this city but no future development.
- ✓ The recently commissioned light rail transit (LRT) in Addis Ababa introduce a relatively modern train vehicle traffic control system along its route.
- ✓ Some area in the city is used a smart parking system in building stories.

This implies that the current mobility traffic control and management system in Addis Ababa are still conventional. Already, too much congestion is being observed in arterial road and junctions. And this city is currently being renovated with the construction of new long and wide roads having some overpass and underpasses as well as LRT railways, improved public transport, and providing pedestrian facilities (Sisay Wegayehu, 2008). Generally, this city of transportation system needs more technology to be smart because the main problem is the absence of technology in the existing transportation system which can highly affect the mobility for both motorized and non-motorized especially public transport has already got significant attention by government to fulfil people's demand.

2.7 Empirical review

Smart transportation shows case areas having shared space design approach developed based on mutual agreement among motorists, cyclists and pedestrians concerning the widest possible elimination of traffic controls, light signals and signing. These design approach intended to create a voluntary change of relationship among all the users of public space, a change in social behavior that is to be supported by appropriate smart transport planning**.**

Drachten – Laweiplein node is an inner-city intersection in the Municipality of Drachten (approx. 30,000 residents) in Friesland (the Netherlands) with a traffic volume of approx. 20,000 motor vehicles per 24 hours. The dismal surroundings of this busy junction, and the wide approach roads were congested, dangerous, and did little to foster civic activity. Pedestrian and vehicles routes were inconvenient and unattractive. It was converted from a signal-controlled intersection into a showcase shared-space project involving a roundabout (Hamilton-Baillie, 2007).

Figure 2.13: Drachten – Laweiplein roundabout

The design deviates from the usual characteristics of small roundabouts. For instance, signposting and marking for non-motorized traffic are notable by their absence the pavement and newly created open-space areas are used by all non-motorized traffic participants without any channelization. It had all of the elements of shared space with the exception of parking for obvious reasons Cars always stopped to give way to pedestrians on the crossing (Hamilton-Baillie, 2007). The roundabout is almost unsigned "Roundabout" traffic signs are placed in the middle of the circle. Accordingly, there are no direction or route indicators on the pavement;

cyclists can ride through the intersection without any restriction. The intersection has an attractive design with fountains and places to sit and linger.

The roundabout was observed to operate very smoothly and without significant delays. As smart transport feature it improves the quality of the space there are lighting which react to the traffic volume. The reconstructed square includes a compact roundabout that forms an integral part of a coherent area of public space. Vertical water jets unite the space; their height responding to the volume of traffic.

Despite the volumes of traffic, the informal protocols that have emerged spontaneously among drivers, cyclists and pedestrians allow free flowing movement and a lively, animated public realm to emerge. Intelligent Traffic Signals are installed to minimize the congestion, allocate green time based on needs, to response Quick Detection of Faults. Extending parking spaces to Secured and enforceable, Gives payment convenience to users. CCTV camera also installed in the street light for city security

Figure 2.14: Drachten – Laweiplein roundabout new design

Smart transportation in Singapore

In past 10 years a growing urban population and lack of available physical spaces made traffic management increasingly challenging in Singapore. In total 12% of Singapore land is occupied by road today, with 15% of land area devoted to housing. Continuing to expand the road network

to address the growing transportation demand has not been seen as a sustainable option to address this demand it has been necessary to maximize the capacity of the road network. Policy tools have been complemented by technologies leveraging on intelligent transportation solution along the entire transportation process (EU, 2009).

Road Network	- 3,300 km
Rail Network	- 177 km
Vehicles Population	- 969,000
Car Population	- 620,000
Daily Weekday Trips	- 12 ml

~ 60% by public transport

12% of land used for roads

Actions to mitigate transportation problem in Singapore

Singapore has implemented a sophisticated intelligent transport system in addition to a number of transport initiatives including free public transportation in pre-morning peak hours, a vehicles quota system congestion charges and an extensive public transport system. The city has pioneered the introduction of a variety of technologies to the system.

Good Transport

Attributes – Physical Integration (Seamless Transfers) – Integrated Ticketing (Flexible Payment, Distance-based). Gives payment convenience to users, Varying Road Pricing Charges for different motoring impact and secured and enforceable (Blokland, M. 2004).

Figure 2.15: Singapore public transport and Parking spaces

Intelligent Traffic Signals

Network-based and Responsive to traffic – Allocate green time based on needs – Provide Green Wave on Busy Corridors – Quick Detection of Fault. Now Singapore is one of the least congested major cities, with an average's car speed on main roads of 27km/h (17mile per hour) compared to an averages speed of 16km/h in Jakarta (Blokland, M. 2004)

Smart transportation in London

London has made huge investment in developed the quality of public transport and introduce a variety innovative feature such as e-toll, emergency response system, bus rapid transport (BRT) corridors and metro networks that is reducing traffic congestion and some part of the area also faced with several other transport related solution such as reducing emission of pollutants and this system is known in London which have a positive impact on GDP.

2.8 Research gap

The above reviewed literature has its perspectives about smart transportation that can provide better services such as higher speeds, lower noise pollution, increased safety, economic efficiency, more energy saving and reduced travel time that is updated day by day and introduced new concepts and ideas. In this case different researches are worked on this subject to solve the transportation problem in both developing and developed countries but the research gap is technology difficulties and planning policy system because each researches give the direction to solve existing problem by different theories and concepts but it may not work for all cities especially smart transportation needs city transport planning contexts.

Some researches and documents they define the concept of smart transportation system is in different perspectives on what exactly means of this word and other thing is implementation or practices of smart transportation system application most researches they recommend to adapt this system in order to satisfy people travel need but their criteria of implementation have need economic, technological efforts and government attention, thus cities especially developing countries will get this challenges to fulfil this facilities. During the literature review there are worked researches in our country which is related with smart transportation system in Addis Ababa but there is no research related with the level of applications to manage the traffic

congestion. therefore, the research is tried to fill the gap by giving emphasis on using smart transport application in the study area. In the condition of our country this system has not given any attention because of these things the condition and life span building is decreasing throughout a time. This research can foresee what will happen in the future, due to the fact that every person living, working or even who made a visit within the city is affected or touched differently by the existing transportation problem, leaving aside it needs practices of smart transport system in this area. It has expecting to show how the transport problem has affected the passenger of Megenagna in different way. The research provided relevant recommendations and suggestions in accordance to the nature of the findings as well as related to the current national transportation policy.

CHAPTER THREE: MATERIAL AND METHOD

3.1 Study area description

The study area is called Diaspora nodal spaces. This junction found in major sub center of Addis Ababa located at boundary of bole and Yeka sub city, It act as junction because it is a place were four paths meet and, it acts as transport node because of the presences of megenagna terminal is found nearby. This roundabout junction is a channelized intersection at which all traffic moves anticlockwise around a central traffic island and the main road is led from Arat Kilo to Kotebe.

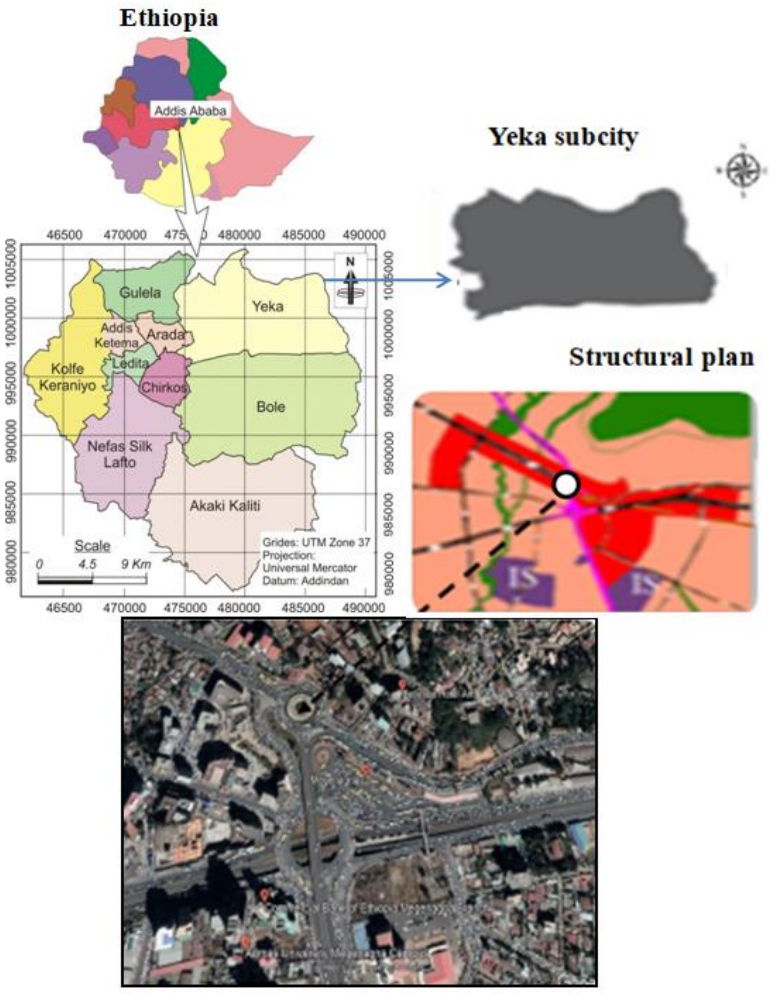

Figure 3.1: Location map of study area

3.1.1 Street overview

Within 60 m radius of this nodal spaces there are different transportation center which includes Megenagna terminal and it's one of the largest transport nodes with variety of choices of public transportation that generate high flow of people. The road are paved with asphalt, terrazzo, concrete and gravel but those paved with asphalt and gravel has low quality, less smoothness and less attractive because of lack of maintenance and missing pavement which led to accident like falling, losing balance.

Figure 3.2: Megenagna nodal spaces street activities.

3.1.2 Amenities

Diaspora roundabout has a little number of amenities which includes streetlight, directional and transport station indicator sign, and traffic signs like yield sign, no turning and parking sign. But they are supportive to cars because they face toward the traffic lane, give service to car users and also, they are not human scale. Other than those amenities there is no other furniture like benches and shades, public toilets, garbage can, information board, way finding sign, pedestrian

sign which makes sidewalk less visible at night, unattractive because of information posted on fences and poles, exposed to direct sun light, wind & rain and full of detritus. This will discourage people presence and comfort.

3.1.3 Road network pattern

The street network pattern has irregular pattern, junction point and have different types of road way that link to the study area especially peripheral arterial street is mainly link to the surrounding road type. The existing road types are paved with asphalt and gravel have low quality because of lack of maintenance. Side walkways also exposed to direct sun and rain, wind and fast-moving traffic because of absence of buffer that can provide physical and psychological buffer from fast moving traffic.

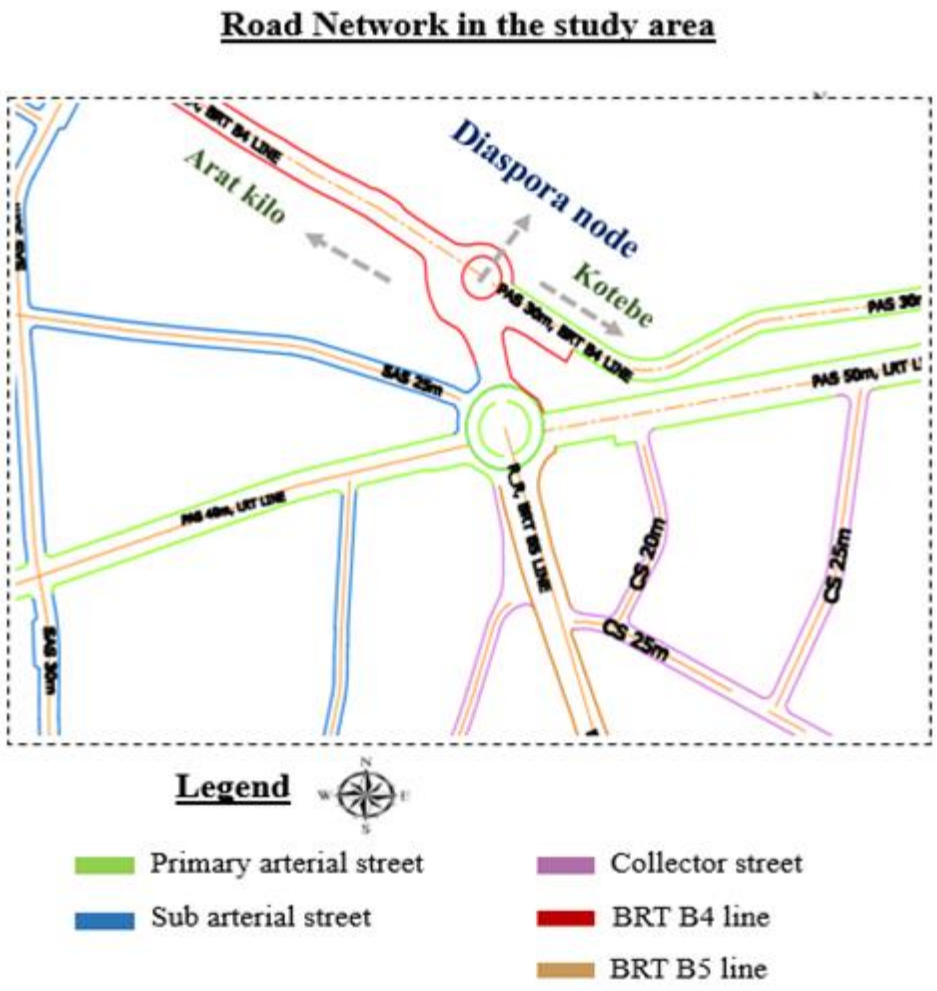

Figure 3.3: Megenagna nodal spaces street network linkage

3.1.4 Land use

These nodal spaces is imbalance use of land because the area is large commerical areas and dominated by terminal and building rather than road network which provide variety of function. it also show dispersed development and segregation of land use which discourage the vehcle movement this makes the node spaces high density car oriented environment. Generally the land use map show there is a lack of balance mix.

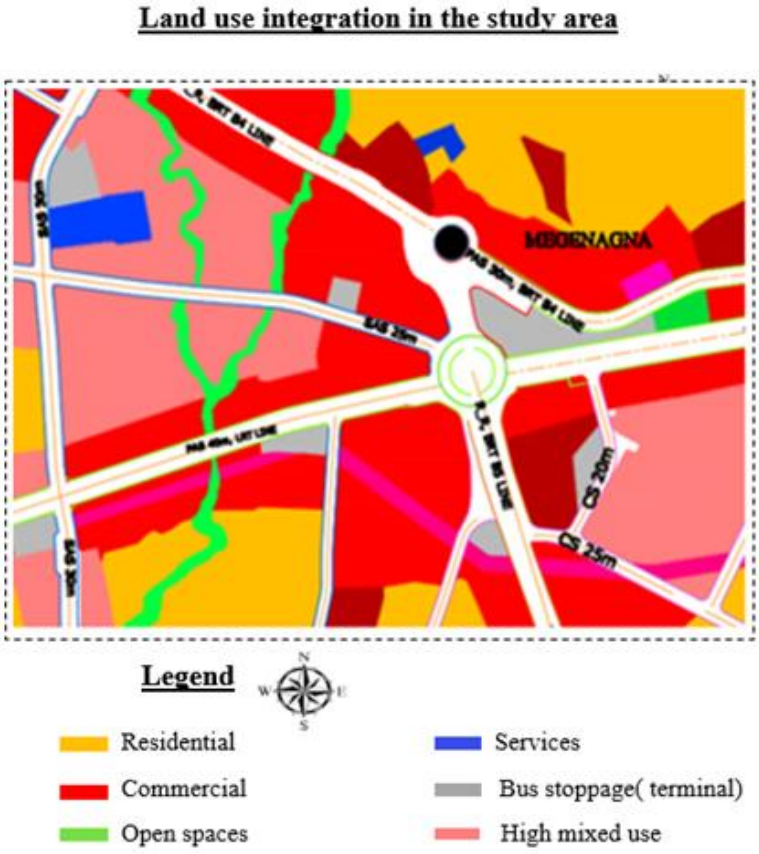

Figure 3.4: Megenagna nodal spaces land use map

3.2 Traffic Condition

The construction of infrastructure network like road network, roundabout, pedestrian walk ways, traffic signs, road markings and service provision in a way that facilitate the traffic flow is the main policy issue proclaimed in the transport policy of Addis Ababa but the study area is affected by high traffic flow because of increasing the rate of vehicles and lack of traffic management applications lead to an increase in road safety risk for communities along such routes especially for vulnerable road users.

3.2.1 Public Transport Network in the study area

The public transport network of the study area is limited in extent and spatial coverage, with the network being more concentrated at the center. In the study area there is no bus lanes or bus priority at traffic signals. The inadequacy of the road infrastructure is also reflected in the poor performance of the city bus and these problems arise from the limited deployment of buses and lack of integrated public transport and built environment planning.

3.3 Methodological Design

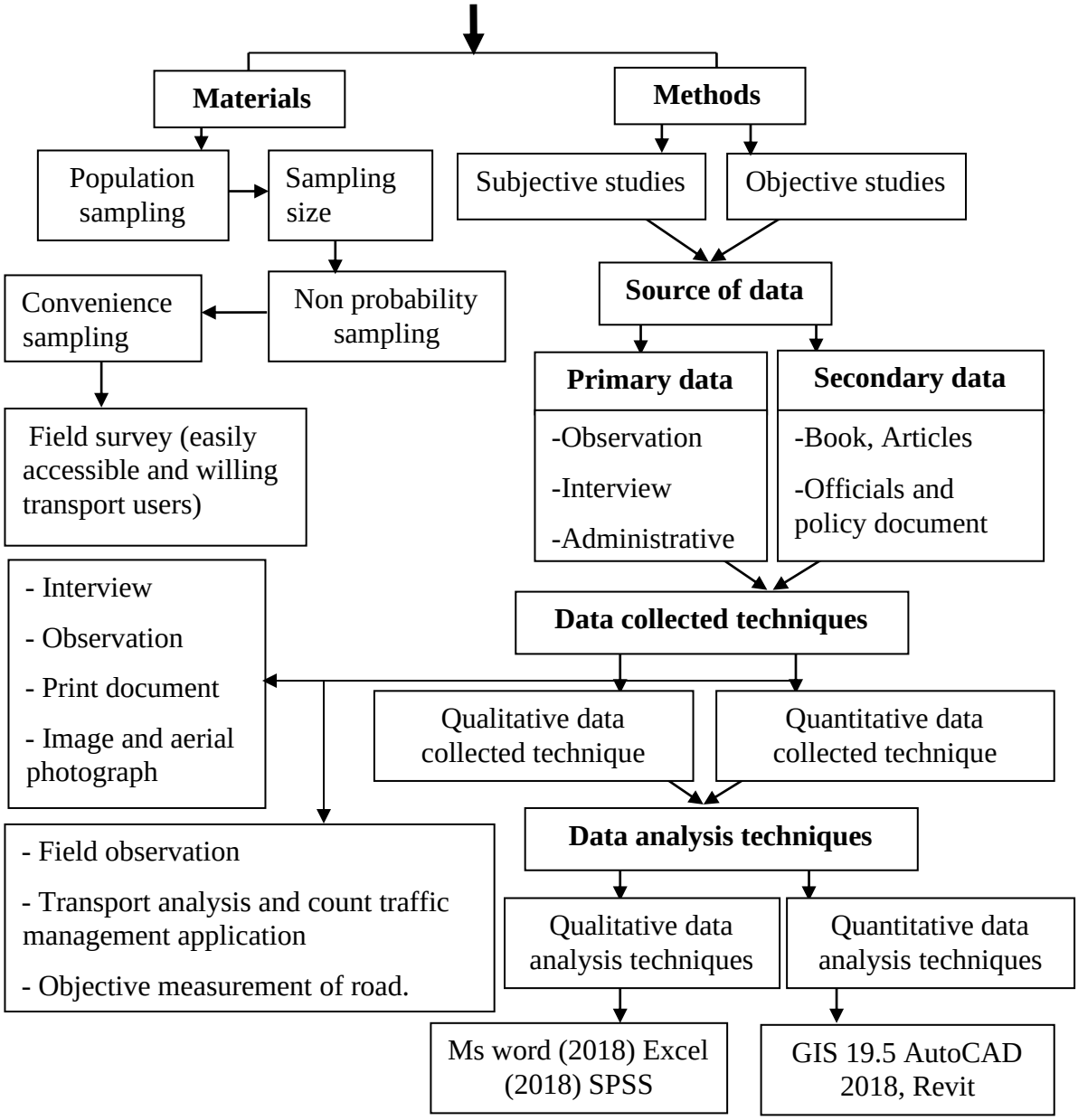

Figure 3.5: Methodological design (Source: Own design, 2023)

3.4 Selection criteria of the study area

The case study area of the research was selected based on different criteria which includes firstly; The existing condition of transportation system is not comfortable. Secondly the site is best locations for node development and enhance image of city but less using of transport management tools and information technologies leads to traffic congestion.

3.5 Sources of Data

The study has used both primary and secondary data source. Primary data like the existing reality on the field (observation), count number of lane, road width, count traffic managing elements, find smart transport applications and sample selected members are collected through structural and semi-structural questionnaire of open-ended type. The secondary data were collected from various policy document urban development plan, official document, Article and important published and unpublished document relevant for issue under study.

3.6 Data Collection Techniques

The study had employed both qualitative and quantitative data collection techniques

3.6.1 Qualitative data collection techniques

The data that was related with concepts, opinions, and value, filed notes from observation of certain activities and image captured were collected qualitatively. In this case field survey was mainly necessary to understand whether transport user, car driver and traffic polices what they say to do and to access unstated knowledge of subjects.

3.6.2 Quantitative data collection techniques

To investigate the asked and observed numerical data, the quantitative techniques was employed. Quantitative data was collected through: field observation was employed to understand and express the character of the study area, to investigate the major problem and potentials of the study area, to survey the width of the road and setback.

3.7 Sampling

The study had conducted an onsite user transportation questionnaire survey even though the total population is infinite. Thus, the study had employed a conveniences sampling technique

for the study. Cochran's formula (1963), had used to determine the sample size since the population size is infinite for street survey.

n= z ^{2} (p (q ((e $^{2)}$ Where,

n= the desire sample size,

z= confidence level at 95% (standard value is 1.96)

p= the estimated proportion of attribute that is presented in population with 50%

q= 1-p

e= designed level of precisions with ±5%

5% with the standard value of 0.05 for this study.

$$\mathbf{n= (1.96)^2\ (0.5)\ (0.5)/\ (0.05)\ (0.05) = (3.84)\ (0.25)\ /\ (0.0025) = \underline{384}}$$

Thus, the study had conducted 384 sample population size randomly those who were convenient and willing to fill the questionnaire with the following characteristics.

3.8 Data Analysis Techniques

3.8.1 Qualitative data analysis techniques

The qualitative data images, text documents, notes were analyzed as follows.

Table 3.1: Qualitative data analysis techniques

Type	Description
Content analysis	Collected data were processed and categorized into verbal data to classify and summarize data.
Narrative analysis	Collected primary qualitative data were revised for the validity and quality of information.
Discourse analysis	All forms of text data and interview were analyzed.
Framework analysis	Finally, formalizing, identifying a thematic framework and interpretation was employed

Source: from own (2021)

3.8.2 Quantitative data analysis techniques

The data like numeric data collected through census questionnaire and survey have analyzed quantitatively using SPSS and Excel software to analyze and describes the data, map, and diagram, chart, table and figure. Furthermore, the study had used AutoCAD 2018, Revit 2020 used for some detail 3D design and others like Microsoft word and power point for document and presentation. Generally, data collected from both primary and secondary data sources were analyzed accordingly using the concepts of smart transportation system.

Table 3.2: Variable to be evaluate

Indicators	
Characteristics	**Variables**
Transportation network	• Road network (PAS, SAS and CS), road density • Road infrastructure and facilities for pedestrian
Mode of transportation	• Non-motorized &Motorized transport
Parking	• On-street &Off-street parking
Street element and utility	• Landscape, dustbins, street drainage, street light, street bench
Pedestrian facilities	• Crossing zebra • Walkway material and width
Land use	• Integration between the transport and surrounding land use coverage
Roundabout	• Junction standard and Visual attractiveness
Traffic managing facilities	• Traffic light, traffic sin ages and road marking
Technology	• Street camera, Traffic calming & recording equipment's
Transport management	• Traffic flow & Pedestrian flow management • Street vendors management

Source from: Rosales, J.; Parsons Brinckerhoff. (2006); Road and Transport Diet Handbook: Setting scale and potential for livable smart transportation trend.

The system can be evaluated through accessibility, connectivity, transport infrastructure, technology, legibility, traffic management and walkability as the predominant urban variable (Marion. L, 2002). Analysis result of the road network, accessibility, pedestrian walkway, parking, road facilities and traffic managing tools had evaluated by transport infrastructure standards.

3.9 Validity and Reliability of the data

For the validity and reliability of the information, the questionnaire wasn't filled by the respondents themselves but rather by the researchers and other data collectors. Since the study was conducted different ideas from the questionnaire and field observations, the outcome of the study would reflect the actual level of transportation system along the study route, thus the study result would valid and reliable.

CHAPTER FOUR: RESULTS AND DISCUSSIONS

4.1 Questioner survey results

The studies were done on the existing transportation system in Megenagna nodal spaces and identified the outstanding problem of transportation in site which includes both the subjective and objective studies of level of smart transportation system application in the study area. Diaspora nodal space is one of the transport nodes found in Addis Ababa where a variety of transport choice and a high flow of people are perceived. There also bus, taxi and LRT station around it within a short distance. It acts as a center because it is one part of the sub center delineated by the master plan of Addis Ababa even though it does not provide what services a center provides.

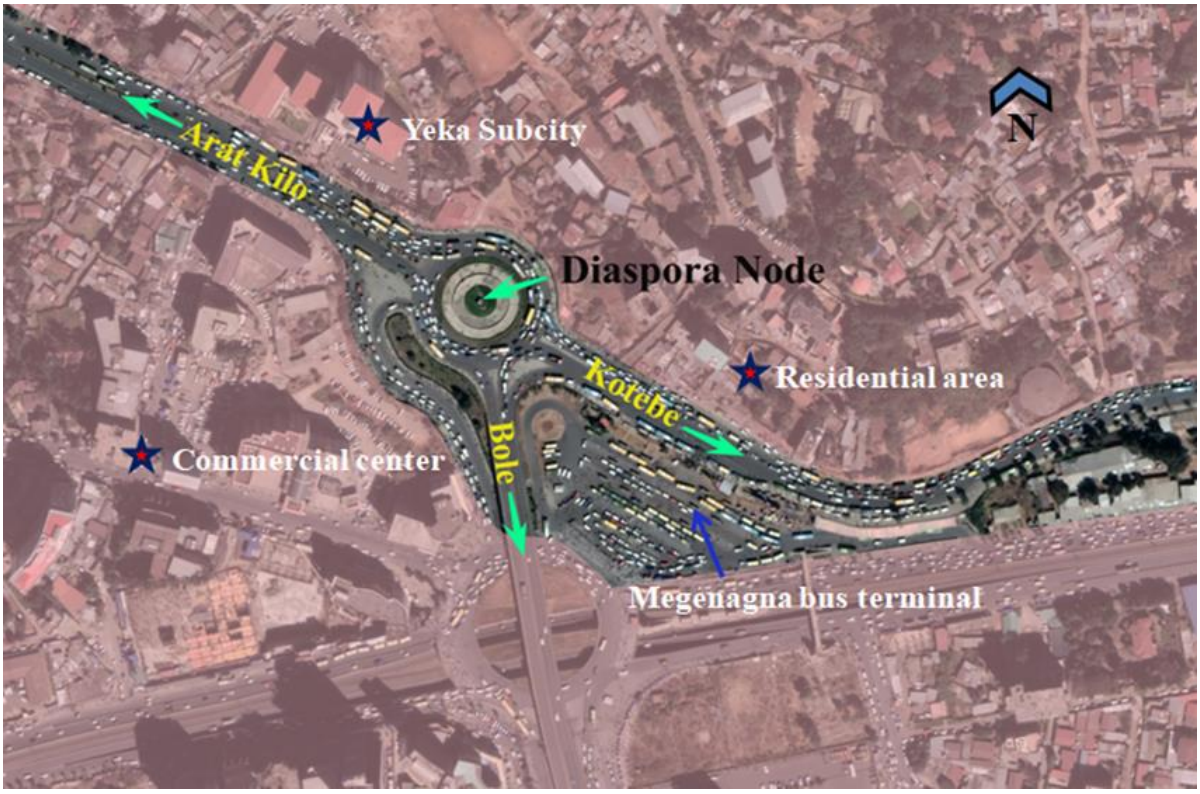

Figure 4.1: Aerial photo of Diaspora node with its surrounding spaces

This nodal spaces accomodates high number of vehicles per day and that makes it increasing traffic flow even if different traffic calming and managing element introduced in the site.

4.1.1 Background of survey respondents

A total of 384 participants, 208(54.17%) female and 176(45.83%) male willing who passing through this road and using this transportation system of Megenagna nodal spaces so all have participated in the questionnaire survey.

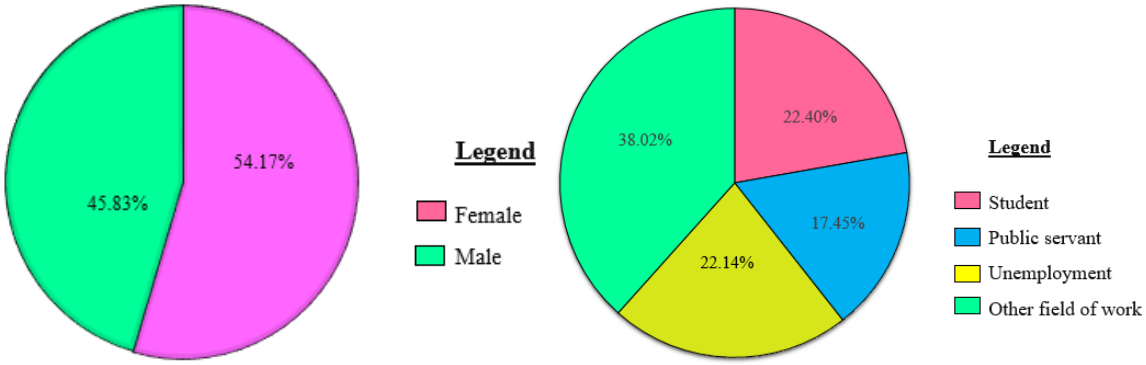

Figure 4.2: Gender and occupation group of respondents

From 384 participants, the majority of people (38.2%) were occupants in other field of work, (22.40%) respondent were students, (22.14%) respondents were unemployment and (17.45%) respondents where public servants involve in this study

4.1.2 Subjective dimension of passenger and driver view about the transport system

4.1.2.1 The passenger view about this transportation system

Any transport user can feel something about their traveling moments and how about their feeling of this Megenagna node transportation system in percentage distribution.

Table 4.1: Percentage distribution of respondent's feelings about the transportation system

	Frequency			
Sex	Good	Bad	Not so bad	Total
Female	6 (1.2%)	122 (31.5%)	80 (21.5%)	208 (54.2%)
Male	4 (1%)	141 (35%)	31 (9.8%)	176 (45.8%)
Total	**10 (2.2%)**	**263 (66.5)**	**111 (31.3%)**	**384 (100%)**

Source from: research survey data (2021)

Table 4.1: shows that the passenger or transport user view about the transportation system Among the conducted survey, 66.5 % (31.5% female and 35% male) respondents said this

transportation system was bad. However, 1.2% female and 1% male respondents said this transportation system was good. From survey data those respondents almost half of the peoples didn't know what exactly look like the area is, so it's hard to answer the question. And 21.5% female and 9.8% male of respondents said about this transportation was neither good nor bad which means it depends on the time to get the transport for them, sometimes they may get the taxi or bus in afternoon times so their view was not so bad. On the other hand, in the morning time there is overcrowded so it's hard for them to get the transport, generally it depends on the time of getting transport services. Additionally, most respondents were also suggested about the noise pollution.

4.1.2.2 The passenger view on security tool and street crossing

Among the conducted-on street survey questionnaire about safety and comfort. In this area of transportation system, there is no security tool like CCTV camera and the existing of high-density population of passenger and street vendors which is informality is causing a crime rate to this area.

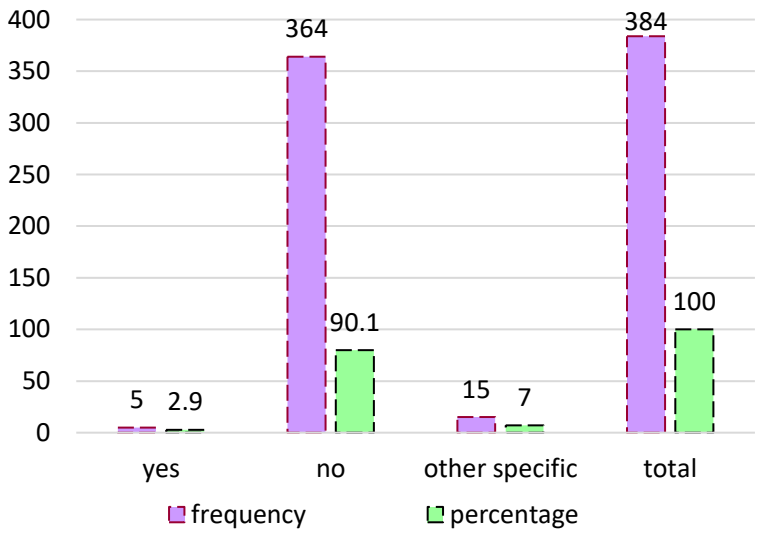

Figure 4.3: Passenger or transport user perception on security and street crossing

Figure 4.3: illustrates that the passenger's perception on safety of the transport system and 90.1% or more than 300 respondents' state that they didn't secure especially when they were crossing the street. 2.9 % or less than 10 respondents were feeling secured on this transport system. And also 7% or more than 10 respondents gave other specific regarding to the management of transport system with different reasons.

4.1.2.3 The passenger time taken to get the transport

The table below indicates that 121(37.3%) take <30 minutes, 190(46%) take30 minutes - 60 minutes, 57(16.7%) take 60 minutes - 90 minutes and 6(2%) take 90 minutes - 120 minutes they take to get the transport because of congestion the majority or 46% of passengers were wait to get the transport from 30 minutes - 60 minutes.

Table 4.2: Percentage distribution of respondent time taken work place from where they live

No	Time taken to get the taxi	Frequency	Percent
1	<30 minutes	121	37.3%
2	30 minutes - 60 minutes	190	46%
3	60 minutes - 90 minutes	57	16.7%
4	90 minutes - 120 minutes	6	2%
	Total	**384**	**100%**

Generally, this area takes long time to get the taxi as respondent said especially employees in the morning time couldn't get the transport because the number of passengers was so high as comparing to the existing bus and taxi as a result, they persuaded to waiting the transport for a while.

4.1.2.4 Pay more than the stipulated fare

The table below shows that 220(57.2%) were forced to pay more than stipulated fare, and 164(42.8%) are said No, that means they can pay the stipulated fare. Generally, this area has need toll management because people were suffering with this force to pay more.

Table 4.3: Percentage distributions of respondents by pay more than the stipulated fare

No	Forced to pay more than the stipulated fare?	Frequency	Percentage
1	Yes	220	57.2%
2	No	164	42.8%
	Total	**384**	**100%**

Source from: research survey data (2021)

4.1.3 Objective Dimension of Level Smart Transportation system in the study area

4.1.3.1 Increasing private vehicles in the study area

The graph illustrates that the passenger's view on the level of high personal vehicles existence mentioned 1 % (0.5 female and 0.5% male) respondents were strongly disagree on this cause, 1.8 % (0.7% female and 1% male) respondents were disagree, 16.8 % (6.3% female and 10.5% male) respondents are neutral, 47.7 % (28.5% female and 19.2% male) respondents were agree. And 33.1 % (13.1% female and 20% male) respondents were strongly agree. Generally, this area of transportation system was covered by high number of personal vehicle and a smaller number of public transports. So, the area is lead to congestion by this cause.

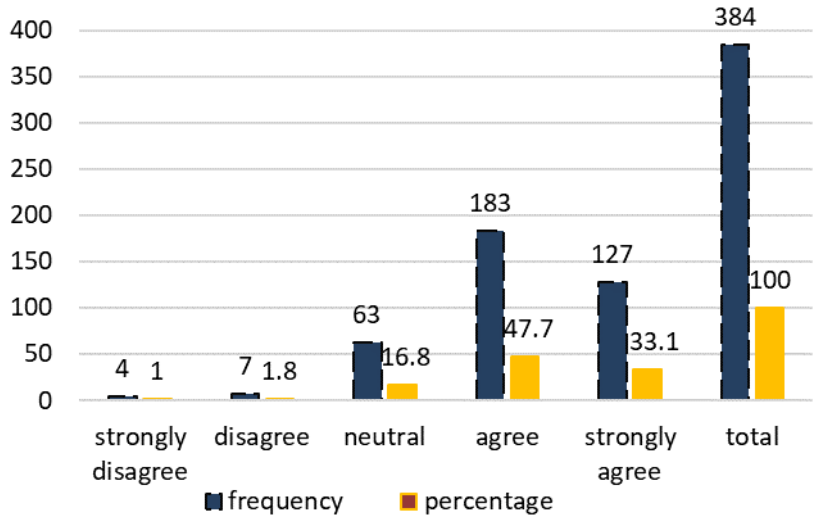

Figure 4.4: The existence of high number personal vehicles

This area has high personal vehicles which is fit with the road width. So, it makes congestion and give a way to happen traffic accident with the traffic management activity is very weak.

Figure 4.5: High number of private cars in the study area

4.1.3.2 The existing reduction of road spaces in the study area

Table 4.4 illustrates that the reduction of road spaces in transport user view. So, it's mentioned 8 % (5% female and 3%male) respondents were strongly disagree 1.8 % (1% female and 0.8 male) respondents were disagreed, 21.6% (13.5% female and 8.1% male) respondents were neutral, however, 40% (25% female and 15% male) respondents were agree and 35.2% (9.7% female and 25.5% male) respondents were strongly agree on the reduction spaces.

Generally, from this data reduction of road spaces was the main cause for transportation problem Moreover 60 % of the respondents suggest for road spaces, using multiple lane and design in street standard can reduces the transportation problem but if it continues, the congestion will increase. Moreover, the congestion was the effects of reduction road spaces and vehicle volume so it needs more lane and use standard width.

Table 4.4: Passenger or transport user perception on transport problem with the reason of reduction of road spaces due to road construction by sex

	Frequency					
Sex	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Total
Female	1 (5%)	2 (1%)	39 (13.5%)	10 (25%)	165 (9.7%)	208 (54.2%)
Male	2 (3%)	5 (0.8%)	42 (8.1%)	257 (15%)	70 (25.5%)	176 (45.8%)
Total	**3 (8%)**	**7 (1.8%)**	**81 (21.6)**	**158 (40%)**	**135 (35.2%)**	**384 (100%)**

Figure 4.6: Existing Road spaces in Megenagna

4.1.3.3 Weak level of enforcement capability in the study area

Figure 4.7: illustrates that weak level of enforcement capability in the study area. it mentioned 1 % respondents were strongly disagree 2.9 % respondents were disagreeing 21.1%respondents were neutral response, however, 44.5%respondents were agreeing and 33.1% respondents' area strongly agrees on this level.

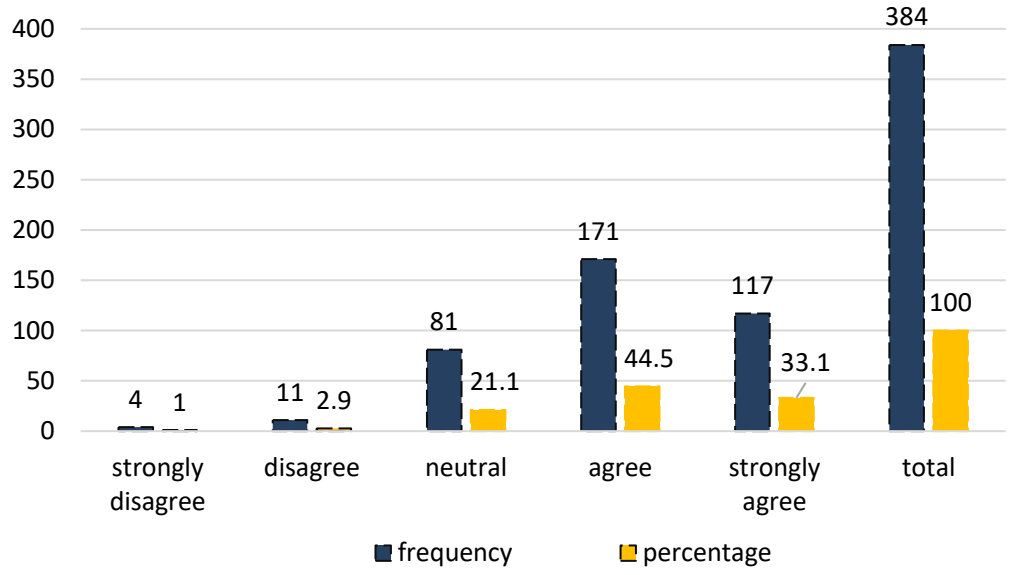

Figure 4.7: Passenger perception on weak level of enforcement capability in the area

Policy, regulatory and enforcement actions are necessary and success depends on these as much as physical measures. As the preamble states, "loss of life, property, and economy of the city due to traffic accidents has reached critical level" and the emergence of new technology, the appearance of new traffic offences, and the "level of development.

4.1.3.4 Traffic Enforcement Measures Effectiveness on Curbing Traffic Problem

Some of the respondents indicate that there is an initiation for the strengthening the enforcement activities in collaboration with traffic police by employing "mobile enforcement", a team base enforcement technique implemented to support the existing activity. And also, different enforcement mechanism has been set by the government, it is only put in the paper as no action has been taken thus far to implement most of the enforcement measures.

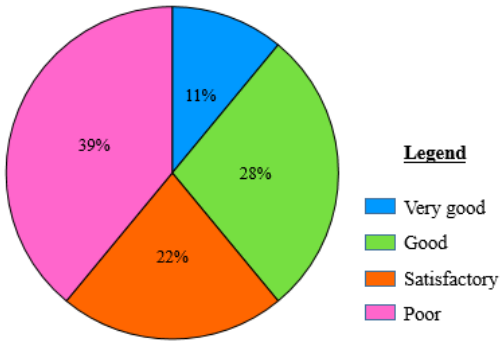

Figure 4.8: Enforcement effectiveness

The respondents were asked to weight the enforcement measure employed in this area to curb the traffic problems and 11% of respondents said very good, 28% of respondents said good, 22% of respondents said satisfactory and 39% of respondents said poor. The respondents also indicate that though enforcement measure has a vital contribution on curbing traffic problem in this area, under study context, the measures were not adequately and properly implemented, there was so many inconsistencies on the practice.

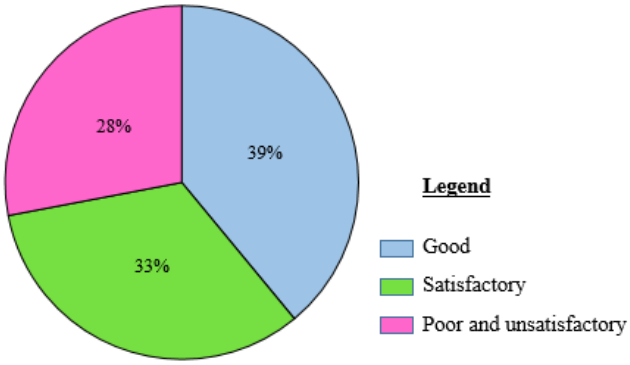

Figure 4.9: Enforcement of traffic polices

Hence as the respondent level of rating the traffic polices plays an important role in the execution of traffic related laws and rules in this area as 39 % of the respondents believe that they have a good contribution while 33% have put their contribution at a satisfactory level. And 28% of the respondent said the poor and unsatisfactory contribution of the traffic police to ward traffic law enforcement in this area. Generally this area of traffic polices were important tools to apply traffic law enforcement in this transport system, they have some weaknesses that in effect disturb their smoothly discharging of their obligation. There was so much ethical problems on the traffic police officers as they were involved in some bribing activities.

4.1.3.5 Poor planned stoppage and on street parking in study area

Table 4.5: illustrate that the passenger's perception on the cause of transport problem as it mentioned, 0.3 % (0.3% female and 0% male) respondents were strongly disagree, 1.6 % (1.1% female and 5.5% male) respondents were disagree, 20.8 % (11.8% female and 9% male) respondents were neutral. However, 45.8 % (27.3% female and22.5% male) respondents were agree and 31.5 % (15% female and 16.5% male) respondents were strongly agree. Generally, this result can show how the bus stoppage is unplanned and can affect the transportation system in these nodal spaces.

Table 4.5: Passenger or transport user perception on transport problem by poor planned stoppage and on street parking.

	Frequency					
Sex	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Total
Female	1 (0.3%)	4 (1.1%)	45 (11.8%)	98 (27%)	60 (15%)	208 (54.2%)
Male	0 (0%)	2 (5.5%)	35 (9%)	78 (22.5%)	61 (16.5%)	176 (45.8%)
Total	**1 (0.3%)**	**6 (1.6%)**	**80 (20.8%)**	**176 (49.5%)**	**121 (31.5%)**	**384 (100%)**

The area has a bus terminal spaces that used for stoppages but it didn't work properly because the lack of land spaces and most of existing buses are parking on the street rather than using the terminal so that make it so hard for crossing.

Figure 4.10: Existing stoppage spaces

4.1.3.6 Vehicle density and population density in the study area

This graph show that vehicle density and population density in the study area. So, it's mentioned, 0.26% respondents were strongly disagreed. And 2.08% respondents were disagreed, 27.60% respondents were neutral, 44.97% respondents were agreeing and 27.08% respondents were strongly agreed. Generally high-density population and no of vehicles were the one it affects the transportation system because it's out of control and it needs some traffic management work.

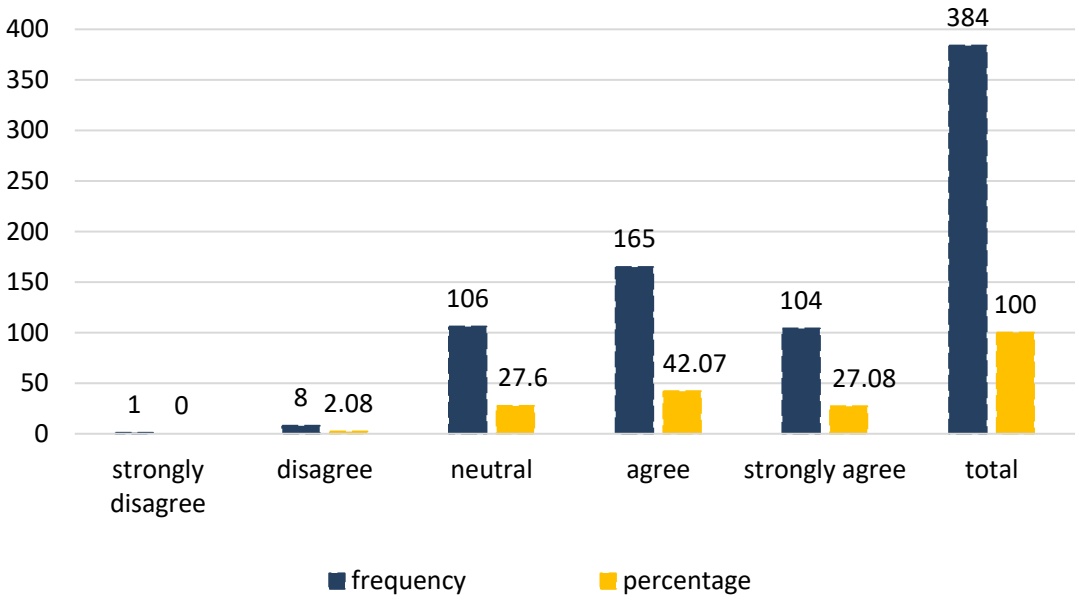

Figure 4.11: The existing vehicle and population density

In this area, the number of population and number of transportations was not in proportion. The total density of transport user was always increasing from time to time but the mass transportation is left behind that's why the area has challenged by personal vehicles.

Figure 4.12: Existing vehicle and population density

4.1.3.7 Less technology of transport management in study area

Table 4.6: illustrate that the less technology of transport management as it mentioned below, 2.1 % (1.4% female and 0.7%male) respondents were strongly disagreed, 14.4 % (10.2%female and 4.2%male) respondents were disagreed, 25.5 % (18.5%female and 7%male) respondents were neutral. However, 41.9 % (20%female and 21.9%male) respondents were agreeing and 26 % (12%female and 14% male) respondents were strongly agree. Therefore, this area have lack of technology as respondents said, the reason why is we can't afford economically and knowhow about technology oriented things.

Table 4.6: The existing less level of technology in the study area

	Frequency					
Sex	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Total
Female	5 (1.4%)	12 (10.2%)	63 (18.5%)	70 (20%)	48 (12%)	208 (54.2%)
Male	3 (0.7%)	6 (4.2%)	35 (7%)	91 (21.9%)	52 (14%)	176 (45.8%)
Total	**8 (2.1%)**	**18 (14.4%)**	**98 (25.5%)**	**161 (41.9%)**	**100 (26%)**	**384 (100%)**

Among the conducted an on-street survey questionnaire about less technology in this area almost have less recognition but it helps to gather, record and exchange information especially traffic polices and drivers needs to use technological material in order to transfer the data from the street to the offices and to reduces their speed by using different GPS, speed control and using the signage.

Generally, from this data most respondents were agreed on using less technology was one of the factors that increase traffic congestion, high crime rate and it may cause loss of life, injuries and property damage just like car accident so that using of different traffic managing technologies can solves transport problems because passengers wants to travel without feel worried and needs comfort so in different way transportation system has huge role and benefits for city economic development.

4.1.3.8 Traffic control measurement in the study area

A. Traffic lights are sufficient

This figure shows us the existing traffic light it mentioned, 20.83% respondents were strongly disagreeing on this sufficient traffic light control 29.95% respondents were disagreeing on this sufficient traffic light control 36.72% respondents were neutral for sufficient traffic light, 11.46% respondents were agreeing to this sufficient traffic light and 1.04% respondents were strongly agree with this sufficient traffic light control. Generally, from analyzed data this area of transportation has no proper traffic light control which is more needed to control the effect the effects of transportation problems.

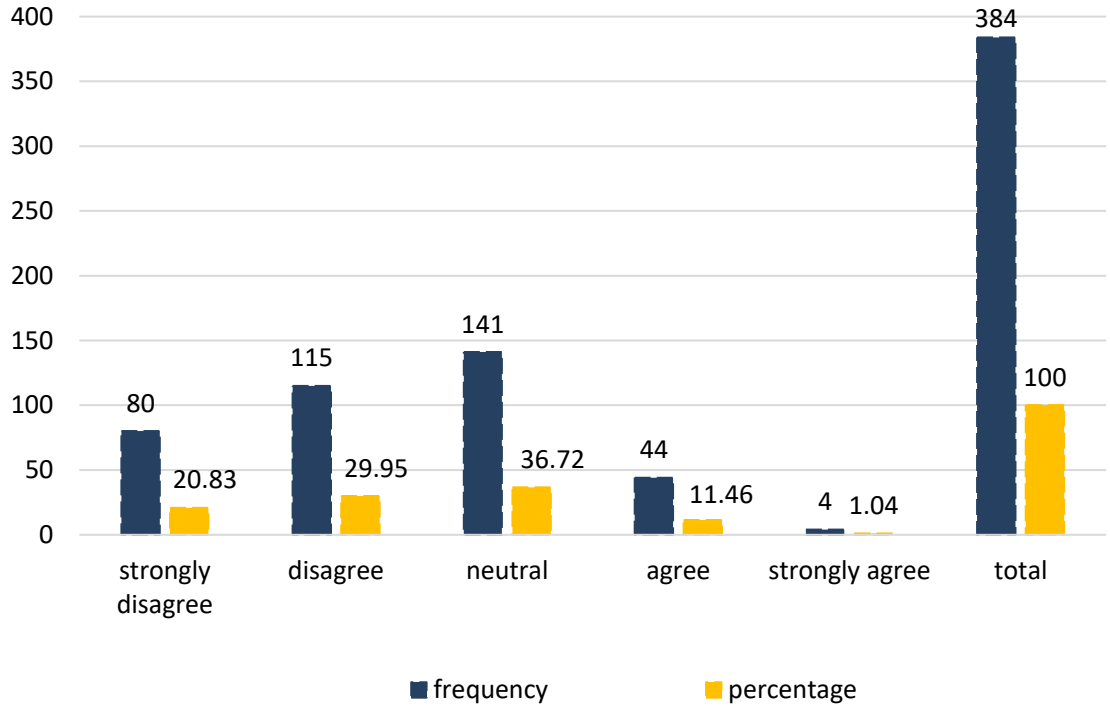

Figure 4.13: The existences of traffic light control

B. Parking restriction is insufficient

Table 4.7: illustrates the passenger's perception on insufficient traffic control it mentioned, 12 % (5.5% female and 6.5%male) respondents were strongly disagreeing with this traffic control of parking restriction, 10 % (6% female and 4% male) respondents were disagree on this traffic control, 18 % (9.5%female and 7.5%male) respondents were neutral to this traffic control.

However, 21.5 % (14.2% female and 7.3% male) respondents were agreed on this traffic control and 38.5 % (16.5%female and22%male) respondents were strongly agree to this traffic control of parking restriction.

Generally, from analyzed data this area of transportation needs more parking restriction.

Table 4.7: Existing parking restriction insufficient

	Frequency					
Sex	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Total
Female	12 (5.5%)	9 (6%)	69 (9.5%)	70 (14.2%)	48 (16.5%)	208 (54.2%)
Male	13 (6.5%)	5 (4%)	61 (7.5%)	42 (7.3%)	113 (22%)	176 (45.8%)
Total	**25 (12%)**	**14(10%)**	**130 (18%)**	**112 (21.5%)**	**161 (38.5%)**	**384 (100%)**

As the respondents' drivers express the magnitude of parking problem in this area, 70 % of car drivers state that they are forced to stop and unload the passengers in the middle of the road due to lack of parking area and sufficient to bear the volume of traffic operated in the area. The thing is there is a negative space which is not suitable to park everywhere but if that spaces will design with its parking infrastructure like shade trees which is preferable for the driver and make simple because they will not worry about the safety of their car and will have quality spaces to all transport users.

Figure 4.14: Existing on street parking in action area

C. Signage and road marking are insufficient

Table 4.7: illustrate the existence of signage and road marking as it mentioned, 20 % (11%female and9%male) respondents were strongly disagreeing on this traffic control, 17 % (10%female and7%male) respondents were disagreed on this traffic control, 25 % (13% female and 12%male) respondents were neutral to this traffic control. However31 % (17% female and 14%male) respondents were agreed on this traffic control and 25 % (10%female and 15%male) respondents were strongly agreed on this traffic control. Generally, from analyzed data this area of transportation systems needs more Signage and marking for traffic control because the flow of vehicles movement was too high and couldn't control to manage so that technological signages is necessary to reduces the congestion

Table 4.7: The existing traffic signages and road marking in the study area

	Frequency					
Sex	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Total
Female	17 (11%)	16 (10%)	72 (13%)	80 (17%)	23 (10%)	208 (54.2%)
Male	14 (9%)	12 (7%)	68 (12%)	55 (14%)	47 (15%)	176 (45.8%)
Total	**31 (20 %)**	**28 (17%)**	**120 (25%)**	**135 (31%)**	**70 (25%)**	**384 (100%)**

Source from: research survey data (2021)

Figure 4.15: Existing Road signage in the study area

D. <u>Speed control is insufficient</u>

Table 4.8: illustrate that speed control is insufficient as it mentioned, 20 % (11%female and 9%male) respondents were strongly disagreed to this type of control. And 17 % (10%female and17%male) respondents were disagreed on this control, 25 % (13% female and 12%male) respondents were neutral to this control. However, 31 % (17%female and 14%male) respondents were agreed on this control and 25% (10% female and 15% male) respondents were strongly agreed on this traffic control.

Table 4.8: Speed control insufficient in the study area

	Frequency					
Sex	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Total
Female	17 (11%)	19 (10%)	72 (13%)	80 (17%)	23 (10%)	208 (54.2%)
Male	9 (9%)	14 (7%)	68 (12%)	55 (14%)	47 (15%)	176 (45.8%)
Total	**26 (20 %)**	**33 (17%)**	**140 (25%)**	**135 (31%)**	**70 (25%)**	**384 (100%)**

Source from: research survey data (2021)

Speed control uses for Safe driving-alerting drivers with safety precautions such as identification of obstacles on roads, a slow-running automobile at the end of congestion, and pictures of the road conditions ahead but in this area almost no speed control but has to be put on the street as most respondents commented.

Figure 4.16: Existing speed control in the area

4.1.3.9 Level of economic effect on transportation system

This graph illustrates the passenger's perception on level of economic effects in transportation system it mentioned, 62.29% respondents were said the level of economic effect was high in transportation system. 5.21%respondents were said the level of economic effect was low in transportation system and other specific 12.50% respondents were describing different reasons to these effects.

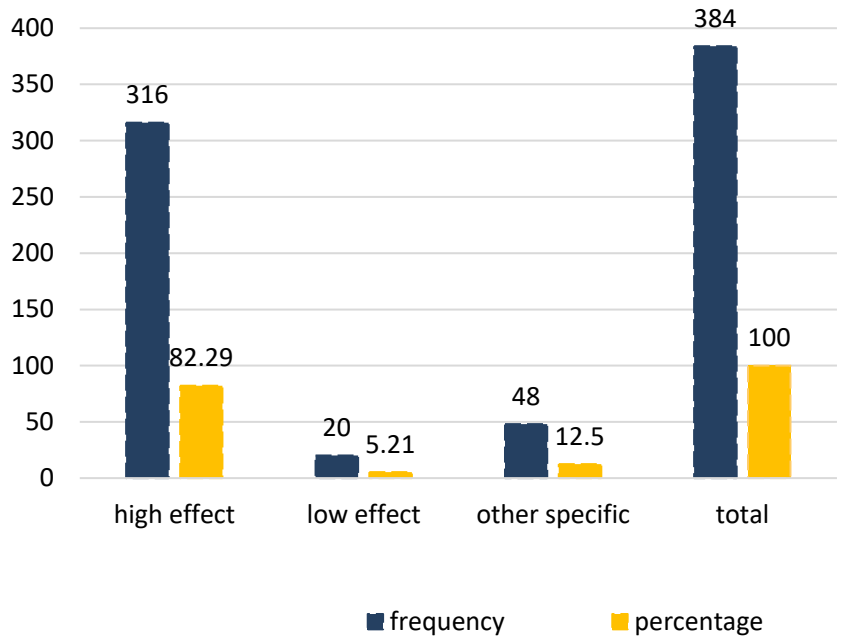

Figure 4.17: Passenger or transport user perception about level of economic effects on transportation system

The economic effect has a major factor for transportation system especially this area has high economic benefits because of the accessibility and there are also peoples have demand to use the transport by any means so the places can ability to get more financial income but the congestion and car accidents also reduces these economic benefits

4.1.3.10 Smart transportation in transport user view

As respondents tried to define smart transportation is the provision of services and infrastructure for the mobility of people and goods that advancing economic and social development to benefit todays and future generations with more access, security, technology and inclusive the disable person as well.

Table 4.9: Passenger perception about smart transportation.

Frequency						
Sex	Available more access for all	Less traffic congestion with less cost	Road security and involves disable person	Improved by technology	All	Total
Female	19	42	30	45	72	208
Male	15	34	42	51	64	178
Total	**34**	**76**	**72**	**96**	**106**	**384**
Percent						
Sex	Available more access for all	Less traffic congestion with less cost	Road security and involves disable person	Improved by technology	All	Total
Female	5.9%	11.6%	8.8%	12%	15.3%	54.2%
Male	3%	8.2%	10%	13%	12%	45.8%
Total	**8.9%**	**19.8%**	**18.8%**	**25%**	**27.6%**	**100%**

Source from: research survey data (2021)

Table 4.9: illustrate that the passenger's perception about smart transportation system as its mentioned, 8.9 % (5.9%female and3%male) respondents were define smart transportation System is available more access, 19.8 %(11.6%female and8.2%male) respondents were defines smart transportation is less traffic congestion with less cost, 18.8 %(8.8% female and 10%male) respondents were define smart transportation means road security and involves the disable people, 25 % (12%female and13%male) respondents were defines smart transportation means improved by technology, 27.6 % (15.3% female and 12%male) respondents were define smart transportation as its all the listed above.

4.1.3.11 Benefits of smart transport system application for reducing transport problem

As respondents said that using different technology has an important to save the driver from accidents like traffic control system have replaced some human driver decisions with machine decisions which also help to achieve smoother vehicle control. The graph below illustrates the passenger's perception about technology benefit to reduce transport problem as its mentioned. 99.48% respondents were said yes and 0.5% respondents were said no due to different reason.

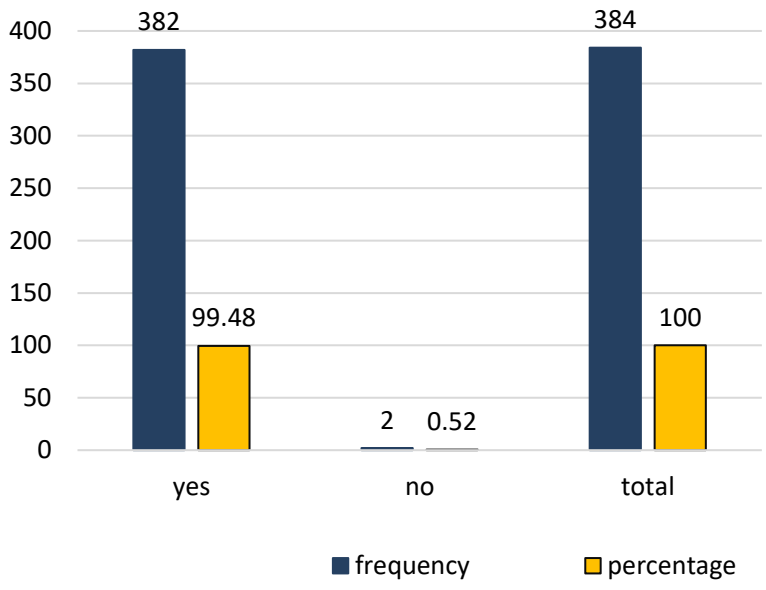

Figure 4.18: Passenger perception about technology benefits for reducing transport problem

4.1.3.12 Ways of practices smart transportation system application

From respondent perception about the way of adopting smart transportation system applications is firstly passenger must get the awareness about transport system that means individual duty is the most valuable, secondly the road needs maintenances and improving public transport system with its infrastructure. So, government should be taking care of the implementation.

Table 4.10: illustrate that the passenger's perception about ways of practices smart as it's mentioned,7.6% (4.2%female and 3.4%male)respondents were said we can practices of smart transport by using different road detectors, camera, speed control and Signage, 20.1% (12.1%female and 8%male) respondents were said we can practices smart transport by decreasing flow of private car, 25.5%(13.5%female and 12%male) respondents were said we can practices smart transport by intervention new strategies of transport plan, 19.5(10.3%female and 9.2%male) respondents were said that we can practices smart transport by maintain and redesign of road construction, 27.3%(14.3%female and 13%male)respondents were said we can practices smart transportation by using all above solutions. In general, to practices smart transportation needs not only using different technologies and road maintenances but also it needs people awareness about the system.

Table 4.10: Passenger or transport user perception about ways of practices smart transport.

			Frequency			
Sex	By using different road detectors, camera, Signage, speed control	By decreasing private car and increase public transport	By intervention new policy and strategies for transportation system	By maintain and redesign of road construction	All	Total
Female	17	58	42	40	61	208
Male	12	40	35	35	54	176
Total	**29**	**98**	**77**	**75**	**105**	**384**
Percent						
Sex	By using different road detectors, camera, Signage, speed control	By decreasing flow of private car and increase public transport	By intervention new policy and strategies of transport plan	By maintain and redesign of road construction	All	Total
Female	4.2%	12.1%	13.5%	10.3%	14.3%	54.2%
Male	3.4%	8%	12%	9.2%	13%	45.8%
Total	**7.6%**	**20.1**	**25.5%**	**19.5%**	**27.3%**	**100%**

Source from: research survey data (2021)

4.1.3.13 Responsible organ to Adopt smart transportation system application

As respondents' perception regarding to the responsible organ to practice the smart transport is everybody should work on together but the government has a main body to this change because the management process needs more strategy.

The passenger's perception about responsible organ in this; practice as its mentioned, 33.33% respondents were said government is the main responsible organ to practices smart transport, on the other hand 66.67%respondents were said all group of passengers, driver and governments were the responsible organ together to practices smart transportation system.

4.1.4 Nodal spaces street condition result by field observation and count the no of vehicles and pedestrian flow

A. Intersection: According to Steiner (2004), number of intersections per area is one of the measurements of connectivity. If there is a high number of intersections it will be easy for movement. In the case of diaspora roundabout, it is well connected with all the roundabout found in Addis Ababa that are located in major road network system which makes it highly accessible and well connected with other nodes.

***B. Visual attractiveness*:** According to Park (2008) transport user perception of conspicuous is one of measured by visual attractiveness which is affected by landscaping and also the streetscape. In order to measure people's perception two questions asked about the existing looking of the study area.

Table 4.11: Perception of passengers on visual attractiveness of roundabout

Feeling about the amount landscaping of the trees	Plenty	Enough	Not enough	hardly any
Number of people	-	-	202	182
Feeling of nodal space	Very attractive	Medium attractive	Unpleasant	Ugly
Number of people	-	**50**	**224**	**110**

Source from: research survey data (2021)

From the collected data the 67% said there is no interesting thing in nodal spaces and 33% of participant feels it is dull.

C. Road material: in order to measure passengers' perception observation asked about this road material.70% of people observed the streets were paved with asphalt, terrazzo, and concrete and gravel Those paved with asphalt and gravel has medium quality, less smoothness and less attractive because of lack of maintenance and missing pavement which led to accident like falling, losing balance and create uninteresting environment. The other part is sidewalk covered with terrazzo, concrete has good and well-maintained quality, more or less smooth texture, attractive color and pattern with few missing pavements.

D. Crossing: According to (Maghelal 2010), the number of crosswalks per intersection is one of measurement of connectivity. In order to analyze existing condition counting of crosswalk and measurement are taken using meter on each path connected to roundabout.

Figure 4.19: Existing crossings in the study area

The study area has only two zebra crossings found on the path that takes to Arat kilo and Kotebe which show less connectivity and opportunity of crossings. It has the same length with traffic lane which is 28m and width of 4m. It is too long and takes an average of 13-20 sec waiting time to cross because of the presence of high number of lanes and absence of traffic calming element and pedestrian facility.

E. Surrounding buildings: Based on the collected data through observation the roundabout is surrounded by many built up environments characterized by large abandoned vacant spaces and buildings bounded by large fence, low rise poor condition shops, under construction buildings.

Figure 4.20: existing surrounding buildings

F. Cleanness of the roundabout spaces: diaspora roundabout spaces is not clean because it exposed to bad odor coming from open ditches, liquid waste and detritus on vacant land, waste disposal inside Megenagna terminal was highly affected by trash pollution so it affects the health and easy movement of people.

F. Traffic volume: this area of traffic volume was too high and not proportion with the width of road especially the traffic flow may damage some property and accidents unless the area can get a real solution as much as possible.

Table 4.12: Number of vehicles coming to the roundabout

Direction of flow	**Time interval**		**Total no of vehicle per day**
	8-9 am	4-5pm	
Diaspora roundabout-Kotebe	942	574	7713
Kotebe-Diaspora roundabout	1366	816	9385
Diaspora roundabout-Bole	272	288	2647
Bole-Diaspora Roundabout	336	285	1796
Diaspora – Arat Kilo	866	671	7223
Arat Kilo-Diaspora	936	902	8787
Total	**4718**	**3536**	**37551**

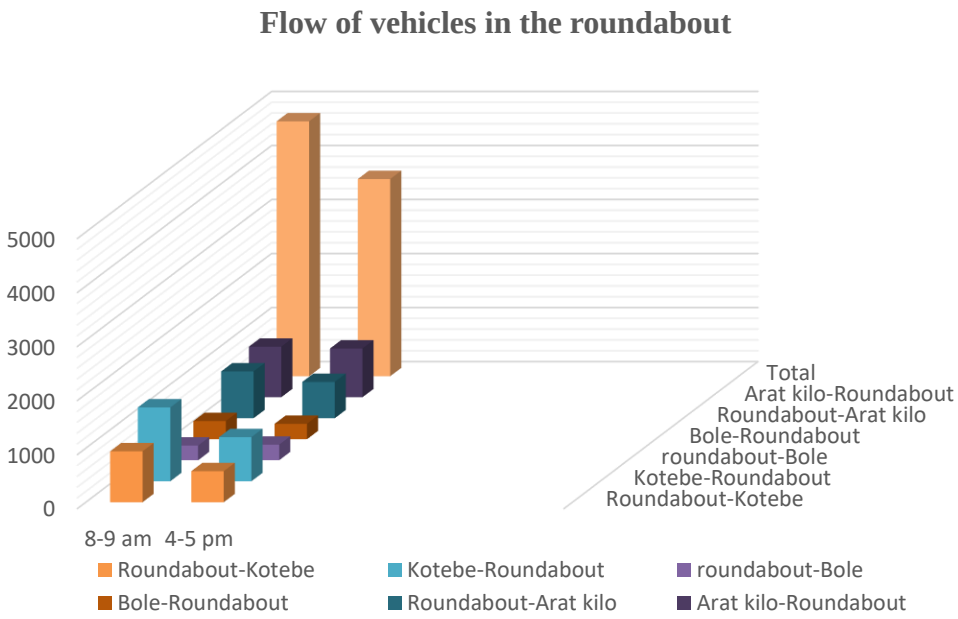

Figure 4.21: Number of vehicles coming to the roundabout

The above data on the table 4.13 shows that many cars come to roundabout especially from Kotebe and Arat kilo direction which is higher than pedestrian flow.

G. Pedestrian flow rate: In order to analyze flow of people in this area pedestrian count is applied two times of a day at pick hour were most people go to and out of work. Based on the data collected the table below shown.

Table 4.13: Number of pedestrians coming to roundabout at pick hour

In the morning time

Direction of flow	**Noof pedestrian flow**	**Time interval**					
		3:00 am-3:10am	3:10am-3:20am	3:20am-3:30am	3:30am-3:40am	3:40am-3:50am	3:50am-4:00am
Kotebe to Roundabout		122	129	105	141	171	134
Arat kiolo to Roundabout		125	102	113	143	212	195
Bole to Roundabout		73	84	69	108	93	105

In the afternoon time

Direction of flow	**No of pedestrian flow**	**Time interval**					
		2:00pm -2:10pm	2:10pm -3:20pm	2:20pm-3:30pm	3:30pm-3:40pm	3:40pm-3:50 pm	3:50pm-4:00pm
Kotebe to Roundabout		138	201	175	143	113	105
Arat kiolo to Roundabout		171	102	127	108	115	179
Bole to Roundabout		201	179	195	174	121	142

Table 4.14: Total number of people coming to roundabout at pick hour

Direction	From 9:00am-10:00am	From 2:00pm-3:00pm
	Total	Total
Kotebe to Roundabout	802	875
Arat kiolo to Roundabout	890	802
Bole to Roundabout	532	1,012
Total	2,224	2,689

Source from: pedestrian count made by Aziza ahmed and data collectors (2021)

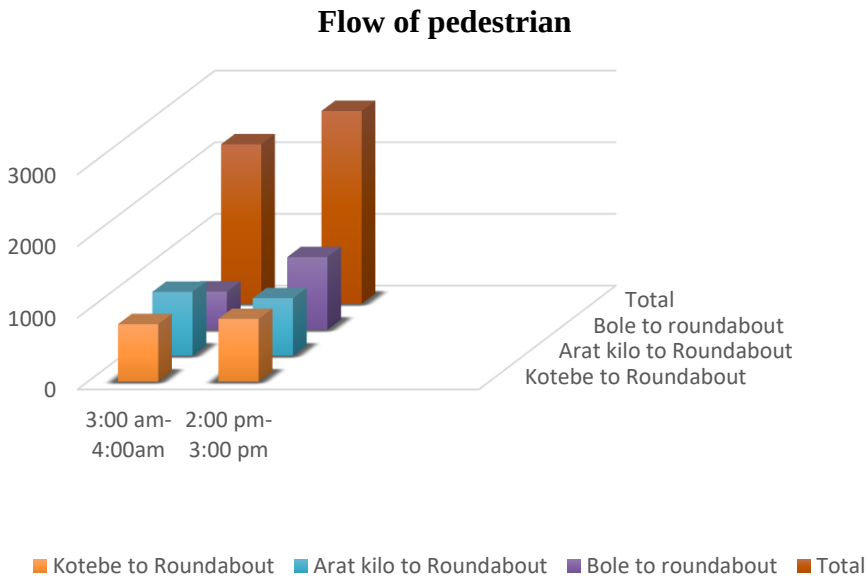

Figure 4.22: Number of pedestrians coming to roundabout at pick hour

H. <u>Weather/climate</u>: According to Maghelal (2010), comfort can be measured by its weather condition using amount of shade and rain cover provided by trees. This roundabouts don ‘t has an area which is covered by trees that provide shade from direct sunlight, rain, wind, sound and air pollution which make it uncomfortable. the surrounding developments don ‘t provide shade but only provide shade for parked cars in front of them and they don ‘t has any kind of structure that provides shade like arcade which shows lower emphasis given to pedestrian by developments.

4.2 Discussion

Objective 1: Assess the existing condition of transportation system in Megenagna, diaspora node.

From data analyzed, this area of transportation system is not in a good situation and highly affected by the level of traffic congestion increases because the transport management still can't control the flow of population density and vehicles movement. According to Handy et al. (2009), road infrastructure is one of measurement to reduces traffic jam and improve sustainable transportation system. Physically the area is connected to the surrounding with stairs, a ramp, level that give access to neighbourhood, terminal and building but those connecting elements are in poor condition because of lack of maintenance.

The existing mode of transport like shared taxi, private car and public transport is not proportional and this uncertain reason is self-evident from the fact that, the revenue generated is decreasing from time to time. According to Steiner et al (2007), the growing usage of motorized private vehicles coupled with the increasing congestion levels led to increased fuel consumption and economically unsustainable.

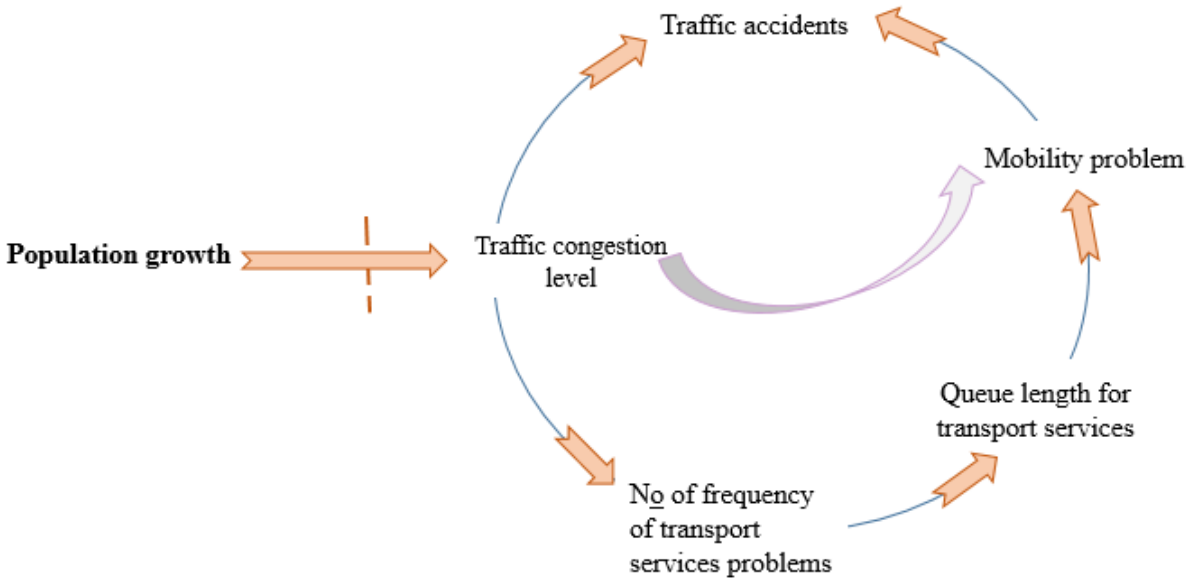

Figure 4.22: system dynamics diagram Causal loop diagram showing relationship between high density peoples, traffic congestion, and mobility

In this area the number of motor vehicles is increasing from time to time at a rate of 3.5% per year which the current investments in transport infrastructure can barely support. According to Frank (2005) transportation problems can able to waste people's energy. In this area it is very common to see people queuing up for a long time on the main roads leads to Kotebe as they try to race for time and it was particularly a source of worry for civil servants because of waiting to use the transport. Traffic congestion delays people to their places of work and the consequence of this is that many working hours are lost on the way, which is a great challenge to the employers.

Transportation system in this area has negative impacts with poor lane discipline by drivers, especially at traffic junctions which deteriorates the already overcrowded junction situation. Furthermore, frequently jump red lights and block the intersection, causing further traffic congestion and this can consequences property damage and accidents. According to Frank (2005) good transportation system is not only concerned about motorized but also for non-motorized because the study area of pedestrian walkway is not visually attractive, the road material is not durable and has no enough infrastructure like bench, street tree, dustbins even the area has only 2 crossing so it's a kind of hard to use walking and cycling.

In the study area different mode of transportation are developed especially walking and shared taxi is more emphasis to the surrounding. The existing public transport like using Anbesa bus gives transport service for megenagna area becaues there is existing bus terminal near by the study area and this transport services is activates only 6:00PM up to 6:00 AM. As the study trys to count the number of ambesa bus in the terminal is only 16 bus found and its lesser than sheger bus but there is high peoples demand to use this types of bus because it has less prices.

Accoding to Brant, (2009) public transportation system should have designed with efficent technology like cameras and television and disables should access the ramp for entering.The anbesa bus are only equipped with global positioning system even have no e-ticketing but sheger buses are equipped with global positioning systems (GPS), security cameras, televisions, eticketing and other facilities to help passengers with disabilities, pregnant women and children for entering the bus easily. Parking system in the study area is mainly dominated by on-street parking, although there are a few off-street parking areas. According to Marvel (2013) off

parking can be measured by lot angle and width. But the area has no enough readily accessible parking areas for personal vehicle which contribute to the inefficient utilization of the road network, especially in terms of road users' safety and traffic congestion.

According to the regulation No7/1998 AACRA is responsible in plan, construct and maintain the city road network based on manual in manner that; improves the liability of community, affords safe travel conditions for all road users, support socio-economic development.

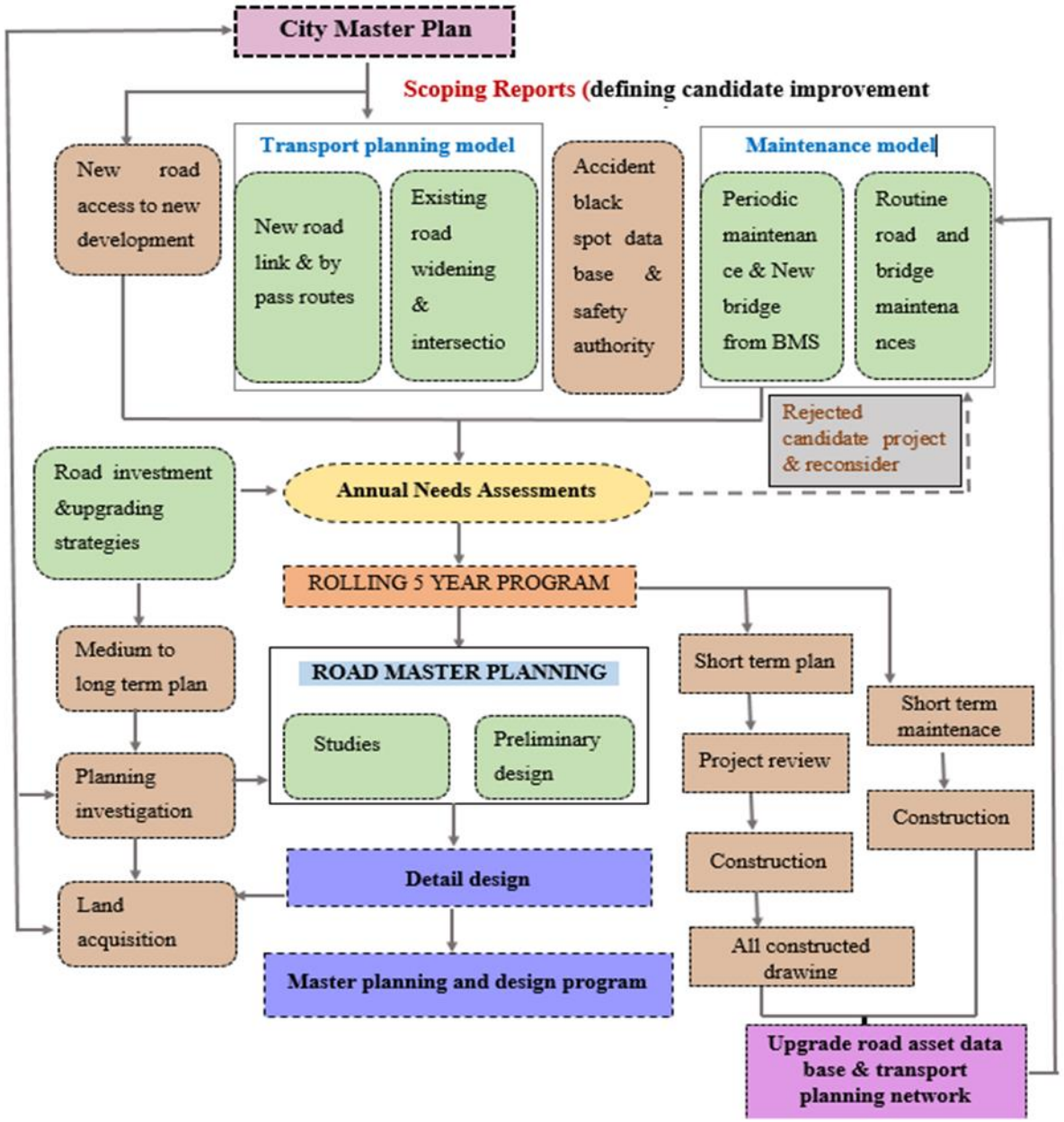

Figure 4.23: phase planning process (Sources from: AACRA,2008)

The study area of transportation system has lack of proper planning especially road maintained and widening are basic solution for reducing traffic problems so road design and construction have need good transport planning integrated with land use planning. The existing condition of land use is not compatible with transportation activities and that make give emphasis to car than other activities. Therefore, the site is affected by traffic congestion. According to Baros (2008) land use mix is one of measurement of convenience that can be calculated using formula written below and it has value range from 0 to 1. If the LUM has 0 values it shows there is only one kind of land use but if it has value of 1 then that area will have balanced mix of all uses.

Pi = proportion of sq. ft of land use; n =number of land use type - ((((***pi*** (/(**(n)**)

Commercial= $1.46m^2$ Greenery= $0.42m^2$ Mixed residential= $0.2m^2$ Residential=$0.4m^2$Road=$1.5m^2$and vacant spaces= $0.15m^2$

LUM= Total area of land use/ no of land use type

LUM= $4.13m^2/6$

LUM= $\underline{0.68m^2}$

This shows diaspora nodal spaces is imbalances use of land coverages also dispersed development and segregation of land use which discourage presence people. So, city master plan should upgrade the transportation system by providing roads fit for their purpose. The vehicle is the primary focus with limited planning scope while the latter approach strives to strike a modal balance through transport and land use integration & prioritization of, walking & cycling. These concepts were also reflected in Bertolini et al (2005) who states that

> *"Urban transport planning from catering for mobility to catering for accessibility may help see how more sustainable travel options (e.g., walking, cycling, public transport, shorter car trips) can, under certain land use conditions (e.g., higher densities, finely -tuned functional mix) provides a competitive degree of accessibility that matches less sustainable options"*

According to Dandina (2006) Classification of road network can be measured by its road width, PAS=40m-30m and average trip length is 15-25ml

SAS=25m-35m and average trip length is 7-20ml

CS=20m-30m and average trip length is <7ml

LS=15m-25m and average trip length is <5ml

According to ACCRA, Road Availability/Density can be measured by: total road network length & area. The road density explains how dense the road network is in the study area

Formula and calculation method: RD = Total Road network length/ Area

$$=2.1km/1.5m^2$$

$$=\underline{1.4km/m^2}$$

The study area has good road linkage because the existing and surrounding roads like primary arterial road is 36m, sub arterial road is 30m and collector road is 25mso with regarding to road width, the existing road network is well integrated. And also, the road density is enough proportion but the road material is not suitable especially the carriage way faces fatigue and the pedestrian walkways is also cracked.

Transport management in the study area has got problems because of lack integration between profession and stakeholders. According to Bellen (2009) The major aim of transport policy is to ensure traffic management system that enable to provide efficient traffic flow, safe and comfortable transport service in the city; to benefit from the city transport infrastructure and services in its proper and coordinated way in economic manner. Different policy was proposed in study area sub city but not yet implemented especially street vendor management, noise pollution management, traffic management still problems in study area.

According to Kanol (2005) sustainable transportation can be measured by proper fare paid system. The study area has a rule for paid system but some drivers are violating that regulation and persuades peoples to pay more than stipulated fare paid so their lack of strategy implementation. According to Karlosma (2008) average number of traffic lanes is one of measurement of coexistence of motorized network. Form the site observation the Diaspora roundabout especially the existing path led to arat kilo and Kotebe were larger size of traffic volume generated because it has only one entry lane so if the number of lanes is decreases, the volume of traffic will be increases. Technology in the study area of transportation system is somehow good but have no quality especially for traffic calming like traffic light, GPS etc are important but in the transportation system there is no e-ticketing.

According to Alebrtan (2011) smart technologies can improve transportation system in sustainable way, effective to manage the resources and control traffic congestion. But the study area has the absences of transport equipment technologies. According to Luis (2004) transportation has a big role on economic growth for a city and can be measured by less damaged property and by system quality. the study area has an opportunity to grow on economic because the transportation system is so active and generally, transportation system in this area

- Transport Capacity is limited
- Service lanes are absent.
- On-street parking is prevalent and pavement condition is deteriorating.
- Pedestrian traffic is very high but level of service is low.
- Parking is emerging as a major demand and problem. Accumulation is high and short-term parking dominates.
- High demands of public transport but less supply
- High informalities like street vendors and shoe shine boys around the spaces
- Limited road signages, street lighting and no street cameras
- The area has no street bench, greenery and less dustbin.

Objective 2: Outstanding challenges of transportation system in the study area

1. **Informality**

The number of populations in this area makes the pedestrian walkway have too much overcrowded and the space is occupied by street vendors so this minimum space required for comfortable walking in relation to commercial built-forms. The minimum area of an average pedestrian is about 0.085 m^2 (Daniel Lirebo, 2019).

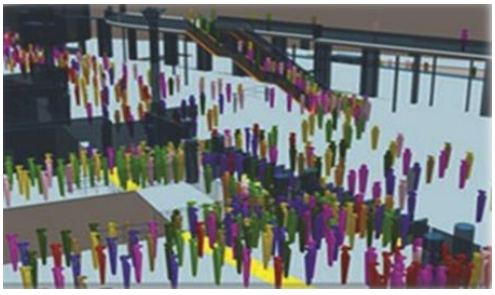

Figure 4:24: poor quality of pedestrian space in building pedestrian friendly commercial built-forms with jam pedestrian density

According to Gallin (2010), conviviality can be measured by pedestrian flow rate and the study area has high pedestrian movement The sidewalks found around the roundabout have width of 1.3-3 m which is more or less enough related to minimum clear passage of 3ft width. But its width varies because of the presence of different permanent and temporary obstructions like failed poles, open ditches, board, bus ticket shop, poles, streetlight, street vendors, stairs and shoe shine.

2. **Poor road infrastructure**

In the study area, there is poor design standard of road material and road infrastructure. From data analyzed the existing infrastructure has lack of quality and some are absenting and that make it increasing the congestion. According to kalim (2008) street infrastructures can treat the level of traffic flow and creates convinces to the transport users.

Figure 4.25:Condition of passengerin the street

3. **Lack of operational and implementation resources**

There are no separate resources which are autonomously administered for scheme planning, designing, implementation and recurrent costs of operations, monitoring etc. Rather, the transport management is both dynamic and staff intensive for preparation, planning, design and operation. And also Continued traffic management requires the provision of adequate on-going budgets for planning, designing, implementation.

4. **Traditional Management Technique**

Existing management system lacks of different infrastructures Intelligent Transport Systems (ITS) seem to play an important role in urban transport management, as cities place them fairly high in their priorities. According to Sanvich (2009) modern transport management considered

as offering potential solutions to many of the cities' problems, with the vast majority of the cities having implemented ITS technologies in terms of providing information to the public and facilitating transport management, or planning. But in the study area has lack of modern management system due to some economically unstability.

5. **Lack of Technology**

In this area, the practice of information communication technologies used in transportation management was poor. From data analyzed there is no alert and warning systems adopted for road safety this indicates that the absence of technological supports in the sector which implies the importance of information communication technology in reducing road accidents. The result showed that the types of information communication technologies practicing for enhancing transport monitoring such as Variable Message Signs is not available and also other technologies such as a car plate recognition system are not used to control traffic congestion as revealed by traffic police only uses partially electronic equipment/gadgets such as speed guns, walkie-talkies to enforce road safety. This indicates that the need to practices and utilize the technology which leads to reduce traffic accident and congestion. So that using of different ICT can improves accessibility and sustainability in economic aspects.

Mobility features in planning sustainable transports system in the study area

Mobility has become a critical issue in diaspora nodal spaceband government is also implementing ambitious plans for rapid economic growth. But institutional coordination is a real obstacle to the design and implementation of sustainable mobility strategies.

Today's planning and urban development decisions will weigh on the cost of delivering access to services and opportunities. Reciprocally, mobility infrastructure may affect the urban form and there is currently no updated transport planning document for area but a Task Force has been appointed to elaborate a Comprehensive Strategic Transport Development Plan based on the new Urban Master Plan, the objective being to refine the Urban Master Plan with detailed multimodal transport modelling. According to Yeka sub city transportation offices, Sustainable urban mobility plans (SUMPs) are critical for establishing a coherent strategy for mobility improvements and prioritizing investments at the local level. But the study area of

mobility features lacks proper planning and has no arrangements both visually and functionally also the existing mobility features has no good standards and may affects the implementation of the new policy and strategy.

According to Pablon. H (2003) sustainable transport can be measured by mobility features.in this case unplanned mobility features can able to dangerous to control the transportation system and this area has different proposed planning but mobility features are the challenges to not implement. So, this area is highly need of sustainable transport planning before expanding transport infrastructure. Policy intervention is very important in these aspects because planning is not only managing mobility feature but also strategies, rule and regulation has a role on the management of mobility feature and to maintain sustainability.

Positive impacts of smart transportation city initiatives on economic development

According to Fernado, (2014) The rate of urbanization globally has been rising and, in 2008, for the first time in human history, the proportion of the worlds' population based in urban areas was greater than 50 percent and cities need to help ensure that their transportation networks can support this high and increasing level of human and economic activity based in cities. Practice of smart transport contributes directly to economic activity and employment through bus, rail, road, air and maritime service. The main role of using smart transportation is helping to creates job opportunities especially in our city unemployment is a big issue and needs sustainable solution for our growth of GTP. But now a day in the study area, transportation has not high benefits for economic development because of unintegrated management and facility.

The other role is cost minimizes of congestion According to Fernado, 2014) Congestion pressures faced by cities are worsening over time and cannot be ignored traffic congestion in different urban areas. It also negatively impacts quality of life by decreasing personal and business productivity, lowering air quality, creating noise pollution, adversely impacting health, as well as leading to the waste so smart transportation reducing these types of incidents could help reduce congestion occurring.

How to level up smart transportation system applications for this area?

According to (Alan Bleak, 2005) Smart transportation plan has the following objectives:

Environment	Protecting historic built environments as well as the natural environment.
Economy	To use transport to ensure that the economy prospers.
Safety	To ensure the safety of all road users, but especially vulnerable road users and pedestrians, who are disproportionately represented in accident statistics at present
Social inclusion	To meet the transport needs of all social groups.
Accessibility	To make sure that, as far as possible, all destinations become easier to reach, although not necessarily by all modes of transport. (a) Improving traffic flow: • Signalized junction controls can improve traffic flow and reduce air pollution. • Urban traffic management and control can enable police, local authorities and public transport operators to share information and help develop a truly integrated and more efficient transport system (b) Improving road safety: • Enforcement cameras deter speeding and discourage traffic violations at traffic lights. • Intelligent traffic signals can increase the time available for people crossing roads, where and when this is needed. (c) Improving security and reducing crime: • Closed circuit television can deter crime and improve response time to incidents • Traffic information services can improve the quality of information available to travellers (d) Improving public transport: - Operators can improve their services by having accurate information on the location.

Intelligent Transport Systems play an important role in shaping the future ways of mobility and the transport sector. We expect that through the use of ITS applications transport will become more efficient, safer and greener (Sampson, 2009). As I mentioned in above, Megenagna nodal spaces has a problem of transportation system so how can we solve this problem and come up with the practices of smart transportation?

Firstly, it is important to work on sustainable transport plan and then provision smart transportation system because he above objectives are must be prioritized and its necessary to integrate with proper land use planning, intervention of transport policy and strategy. For this area, informality has increasing so government has to give some recognition for street vendors, especially eviction is not the right solution but need to give a place for their market and they will have paid some taxes to the government so in this case they can start their work and productive without worried and our economic development will increase. Detailed route planning information (often in real time) for both public transport and car users. Secondly, the existing road design and roundabout has lack of standards so we have to maintain the road width and materials for both the carriage and pedestrian walkways with clear define street elements like street tree, street furniture, street lighting, and dustbin. Thirdly, by using different technologies and information system like Sensors: - To stock any road application, the first thing that need is message from the road. There are several actual modes of sensing: static sensing, where sensors are static placed on the road, mobile sensing, where sensors are placed in the moving car.

The use of geographical information systems (GIS) and relational databases to keep inventories of transport infrastructure in an area (e.g., the condition of the road network) to better manage and priorities' maintenance work. Traffic signal control: it's important to improve traffic signal control to become efficiency of traffic flow, or to afford priority to particular user groups such as bus passengers, or pedestrians, within a network.

Automatic Incident Detection (AID) systems are used to detect vehicles that have come to a stop, vehicles that are slowing down or pedestrians that are in locations that are off-limits. In general, any anomaly present on the network can be quickly detected so as to prevent or at least mitigate any potential adverse effects.

Best Practices of smart parking in Megenagna places

Megenagna smart parking system had practices and is fully operating since June 2017, and is considered as a continental first and its aim is to alleviate the pressure on the surrounding road network. (Tibebu, 2007). This smart parking has the capacity to accommodate a total of 140 cars, out of which 50 will directly on the ground floor. The preserved area around the parking site could also accommodate 70 more cars, tallying up the total ground floor's car capacity to 120 and has a modern lifting system that safely parks cars in a huge steel story building.

Figure 4.26: Megenagna Smart Parking system

This parking system contributes to GHG emissions reduction and air quality improvement by alleviating traffic congestion, through reducing time drivers need to find a free parking space. Furthermore, it also helped solve parking and traffic flow issues in the area by providing more parking plots, accompanied by policies panning street-parking in highly-congestible areas. Moreover, it presented a job opportunity for the peoples, becoming the leading example for other smart parking systems being built across the city. But this parking system is not working right now because of less access of electric power and forced to standstill the services.

Now a day, Addis Ababa's Transport Programs Management Office (TPMO) is making efforts to solve parking issues through the development of optimized parking systems, particularly with the construction of smart parking systems equipped with modern devices, such as cameras and sensor. According to Addis Ababa Master Plan 2017-2027, transportation proposal On street car parking is restricted on major streets (PAS and SAS) inside the inner ring road and will need more providing opens surfaces for parking system to reduce congestion inside the city.

Security in the study area of transportation system is very dangerous According to Park (2009) peoples comfort measured by Sense of security which affected by visibility at night.

According to Rezwan (2008) Efficient and effective smart parking management systems should be:

- On-street signage, consisting of static signs informing drivers of parking regulations on each street and live message boards alerting drivers concerning available parking spaces nearby.
- A GPS based system can be used to track individual parking attendants against a minimum number of vehicles that should be checked per hour
- Mobile apps should be set up to provide live information on available parking spaces and information on parking fees.

And all the above-mentioned smart systems in parking management will have an important role if its practices. But still now in Addis Abeba, there is no places practicing smart transportation system, but Megenagna spaces has a big chance to being practices this system because the places are known by one of the centers for transportation activity in Addis Ababa and the road standard can be improved with in short term so there is no need to demolish the existing road and infrastructure. It's also possible to improve the traffic calming equipment's by using technology oriented to be transport more effective and efficient.

The other thing is this area of Land use policies should encourage transit-oriented development (TOD) within walking distance (i.e., 500 m) of mass rapid transit lines. Master plans should be revised to promote high density, compact developments within 500 m of existing and planned BRT corridors and high frequency Bus corridors. And all this possible way can solve the existing transportation problem of the study area as well.

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CHAPTER FIVE: CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

Urban transportation, which is increasingly becoming inefficient in Addis Ababa and resulting in congestion, can be viewed as a function of various components of the urban transport system problems. These elements are traffic management, and transport infrastructure creating lack of properly planned urban transport in the city, especially Megenagna places is manifested through the low degree of efficiency of urban transportation that is now observed in almost all of the city's center and other major traffic corridors. Diaspora node is a junction found within major sub center of city were four path meet that link city with other region as well as major sub center with the other part of city and effectively function for movement of cars and pedestrians but it has lack of mix of function, less dense development, weak enclosure, lack of physical and visual connection with surrounding, poor quality, well integrated and sufficient pedestrian facilities; lack of attractive and interesting thing to see, large blocks and parking space, absence of blind and disabled facility, sound and air pollution, high traffic volume with fast speed movement and high pedestrian flow. The government also gives less emphasis for transport facility and crossings, signs and other traffic calming facilities as a result transport users has negative perception about the existing transportation system because of less transport management and policy regulation so this problem will be exacerbated in the near future as traffic volumes increase substantially due to the economic and demographic factors.

In general, it has been stated in the beginning that transport is an engine for development, hence the significant role that urban transport system plays in bringing about a sustainable development and poverty reduction in the urban context cannot be overstated. It should be mentioned here too that, as it has been clearly stated in the concluding remarks, diaspora nodal spaces of transportation system face many difficulties related to management and implementation. Therefore, the study further tries to see the reason for this unsatisfactory performance and it is found out that there are internal and external factors that hamper the

transport management practice as it is required in accordance to the magnitude of the problems. And those problems can only solve by practice of smart transportation system because technology has a role on traffic management, security, creates inclusiveness of all society and environmental protection.

5.2 Recommendations

General Recommendations

Based on the results of this study, the following recommendations have to be taken in to consideration. The study identified multitude of factors responsible for smart transportation system and its impact on urban mobility: the case of Megenagna node. This area is highly affected by high population and vehicle density so that uncomfortable and less transport infrastructure is a continuing problem until high priorities are given to the situations and addressed according.

i. It is recommended that, immediate action be taken by government, private sectors and society to create awareness and how to develop to re-organize the network according to the new routes and use different technologies for transport system.
ii. Transportation problems can be solved by improving and encouraging use of public transportation, by encouraging non-motorized transportation; by providing and maintaining appropriate infrastructure and by applying smart traffic management systems so that urban planner should have to work the upgrades of transportation plan.
iii. To make the transportation service more reliable and convenient, the decision makers should implement right-of-way and transit priority measures such as dedicated right-of-way; high occupancy vehicle lanes; express bus routes and priority signalization.
iv. The transport agencies should continuously evaluate the quality of their service provisions on each route and bus terminals
v. Finally, each transportation planner and service provider should use intelligent transportation system during planning and analysis of the transportation service.

5.2.1 Policy and Planning Recommendation

Policy gap is the major pitfall in the development process of Megenagna places that has basically resulted from lack of transport policies: Clear policy, proper planning, strategies and regulations need to be set to correct and control informal activities in the study area that have consequences on public transport and the environment. Moreover, regulations that facilitate control of the private transport providers should be put in place.

5.2.2 Design recommendation

This section of the research shows different principles, programs, concepts and design strategies developed to tackle problems of diaspora roundabout transportation system described in general findings from existing planning and policy by taking in to consideration important concepts of smart transportation from international case studies and also literature review.

Urban Design Principles

- Well integrate and connected roundabout node
- Accessibility and permeability
- Mixity of function
- Mode of transportation and dense development
- Legibility
- Quality public realm
- Increase safety and security
- Economic feasible development
- Technology oriented development
- Eco friendly environment

Planning Program

A. Integrate roundabout with surrounding environment and other nodes

- Increase number of intersection and paths connected to roundabout
- Increasing the number of crosswalks at appropriate location by minimizing its crossing length
- Small block development

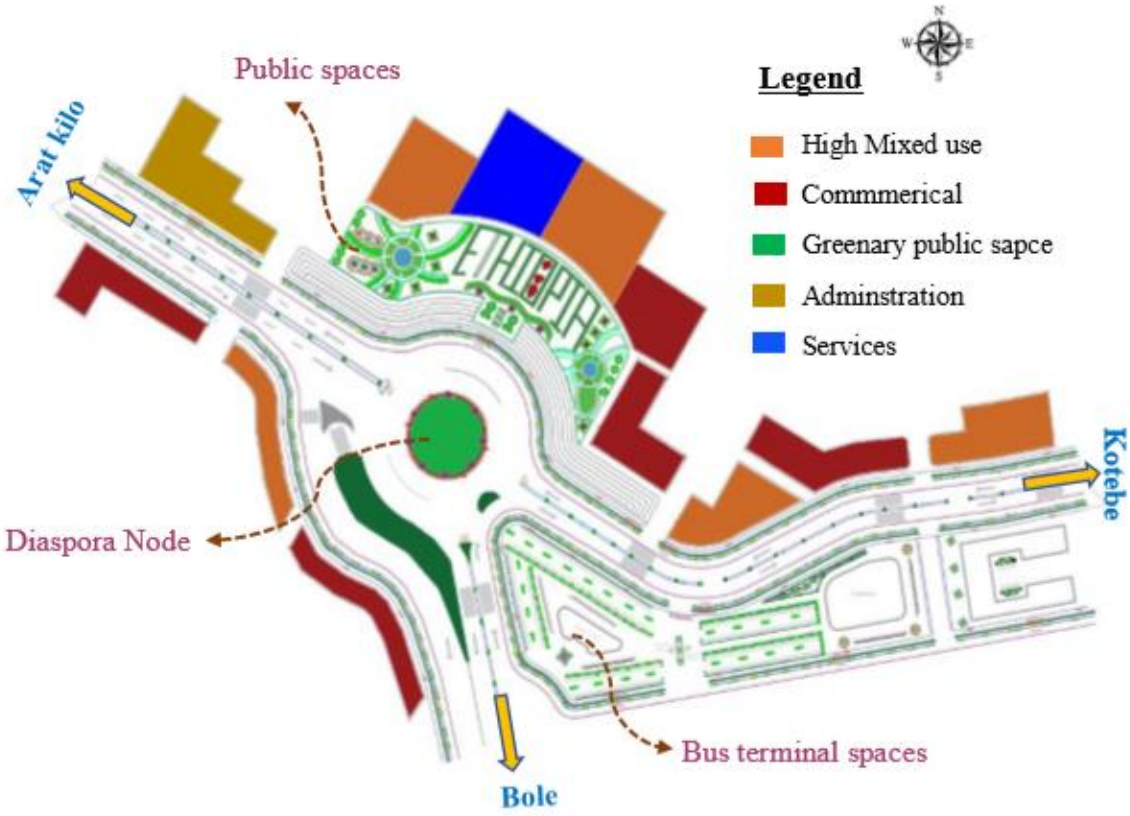
1. Accessibility and permeability
    - Integrate surrounding environment and transport activity both physically and visually
    - Improve road facilities and maximum building set back
    - Improve flexible, convenient and equal opportunity for disable people
2. Mixity of function
    - Provision of variety of functions at one place and balances mix of land use
    - Integrate indoor and outdoor activity
    - Integrate transportation system with natural environments
3. Mode of transportation and dense development
    - Inclusive both motorized and non-motorized
    - Support public transport, walkability and conflict avoidances
    - Encourage high rise dense development on lower dense environment as well as on unused and large boarder up parking areas
4. Enhances Legibility
    - Improve hierarchy of route and spaces
    - Enclosure of public spaces frontage
    - provision of pedestrian scale signs
    - provision of traffic signage for vehicles
5. Quality public realm
    - well maintained, paved, clean and efficient transport infrastructure with absence of obstacles
    - provision of blind and disabled road facilities
    - Development of visual attractiveness and variety of features like landmark
    - Provision of quality pedestrian and carriage way facilities including shed, benches, street light, signage and marking
6. Increase safety and security
    - provision of place for street vendors
    - provision of traffic calming techniques like sign, curb extension at crossing

- street side development on unused and boarder up parking area

7. Economic feasible development
   - large fund for public transport and pedestrian facilities, development of design standards and regulation that give emphasis to both motorized and non-motorized
8. Technology oriented development
   - Improve traffic control equipment's
   - Provision of different sensors for parking system
   - Provision of E-ticketing system in transportation activity
   - Improve GPS and CCTV cameras on the street and public bus
9. Eco friendly environment
   - Improve buffer and shades to protect the surrounding heats
   - Integrate biodiversity and transportation

Design recommendation

2d overall of roundabout spaces



3d overall of the site

 Proposed Integrated Transport System

Integrated Smart Transportation with surrounding buildings

Priority for non-motorized

❖ **Proposed pedistrian, cycle and traffic calming facilities**

Smart street bench have wifi for all transport user

Smart or automatic dustbin have a sensor and can detect the object infont of the dustbin and can recycle.

Smart sinage can regulates the flow of vehicles & pedistrian movement

Smart crossing for pedistrian

Smart marking can informing drivers for about traffic situation

❖ **Proposed public transport system**

Smart public transport system equipped with wireless&communicat ion & globa navigation satellite system

Smart bus station can give an information about the origin and destination of travel places and time.

Smart bus facilities can reduces the wastage of transport energy and have power sources and an internet connection

Smart bus terminal can offer wifi free charging point for electronic devices, & interactive display.

❖ **Proposed Traffic lights with CCTV camera**

Smart traffic light are vehicles control system that combine traditional traffic light with an array of sensor and role in improving traffic flow

❖ **Proposed parking system (Technological oriented)**

Smart parking system fully integrates parking, guidances, payment and as well as a host of other complementary services and allows the detection of parking availability indoor and outdoors.

❖ **Proposed E-ticketing system**

Smart E-ticketing transportation system will be stored on mobile phone or bank card & allows a passanger one way trip in more than one means of transport.

❖ **Proposed Ditch**

Smart ditch can controlling stormwater runoff and control erosion, catch loose sediments and water management lining

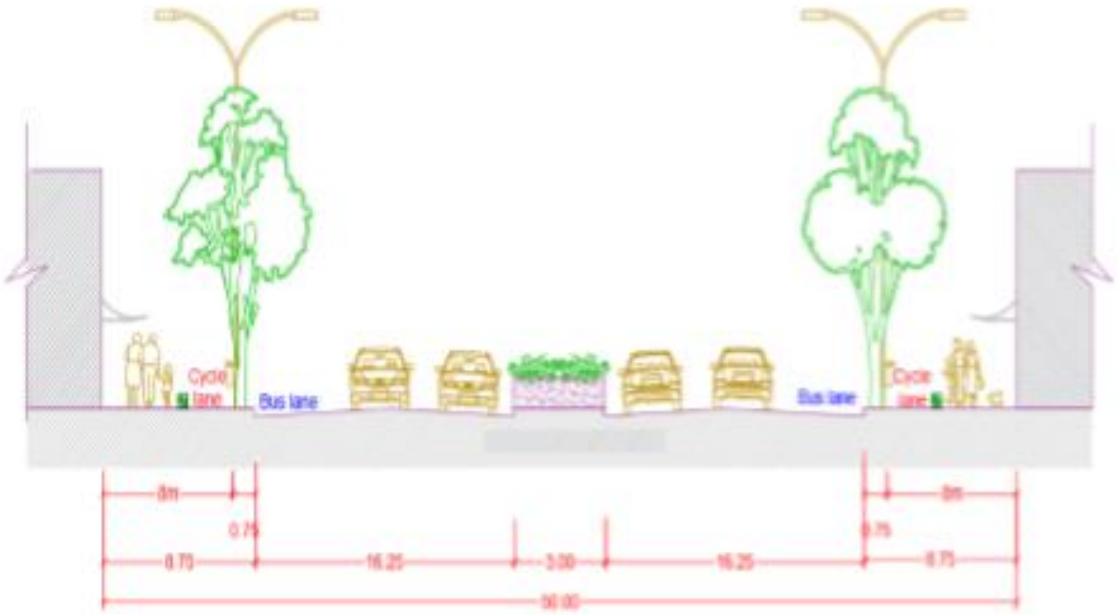
❖ **Proposed surrounding public spaces**

Smart roundabout can allows traffic to proceed with minimal delay and idling time significantly reducing vehicle fuel consumption & emission

Smart public spaces uses technology to assist and help the usage of spaces and has a role on social, culture, economic and ecological level of the community.

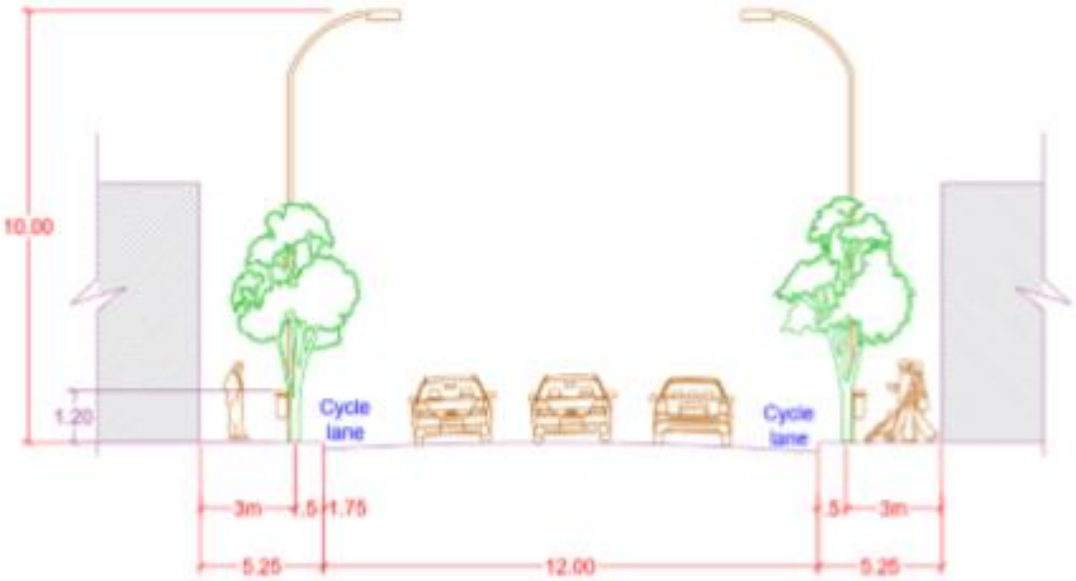
Sources:Own design (2021)

STREET SECTION



PRINCIPAL ARTERIAL STREET

ESC:1/200



COLLECTOR STREET

ESC:1/200

Implementation

1. It is also necessary that transport plan achieve internal, horizontal and vertical consistency, not only at the planning stage but also at the implementation stage of policies. Therefore, integration should link the institutional, technical, spatial, and financial elements together.
2. Planning alone will not guarantee that a particular type of development will occur, rather, policies should consider different traffic management technologies. In addition, focus on sequential land development following an incremental extension of transportation and other infrastructure services from near-by built-up areas could facilitate transit provision. Moreover, there should be a balanced mix of transportation modes with a focus on non-motorized and public transportation.

5.3 Direction for future Research

As transportation activities in Megenagna are predominantly governed by informality and market forces, the role and extent of informality in shaping the spatial structure of the area needs a further study. There will be much to learn about in this aspect to guide the transportation system in a sustainable manner, and it could be an interesting topic to explore, as well.

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APPENDIX

APPENDIX I

Questionnaire for Sample Survey

Name of the place_____ Date _____

Hello, I'm a student at Adama sciences and technology university. And I'm conducted a study on Level of smart transportation system application in Addis Ababa, the case of Megenagna nodal spaces and this questionnaire is designed to gather data on the existing condition of Transportation system in Megenagna, Diaspora node spaces to achieve this purpose and to deeply investigate the case, your response to the questions given below has a crucial value. Therefore, you are kindly requested to read the questions carefully and give accurate and real data which exists on the ground. The response that you reply will not be used for any other purpose other than this research work, so be free and give your honest and genuine response.

Thank you in advance for your Cooperation!

Directions: Answer the questions to the best of your ability. Please put (X) or (() on the box for the answers you choose or fill your answer in the space provided.

1. Gender?
   - ☐ Male
   - ☐ Female
2. Occupation
   - ☐ Student ☐ Public servant ☐ Unemployment ☐ Other specify
3. Are you always using this area for transportation?
   - ☐ Yes ☐ Sometimes ☐ No it's my first time
4. What do You feel about this area of transportation system?
   - ☐ Good ☐ Bad ☐ Not so bad ☐ Other specific_____
5. Which mode of transport do you use?

☐ Walking ☐ Taxi ☐ Bus ☐ Bicycle

6. How long does it take u to gain the taxi in this area _____
7. Have you forced to pay more than stipulated fare? ☐ Yes ☐ No
8. Do u feel secured when u r travel in this area?

   ☐ Yes ☐ No ☐ Other specify _____
9. Do you think this area have some challenges in terms of transportation system?

   ☐ Yes ☐ No

If your answer for question no 9 is yes

Part 2: Please answer the following transportation management system work on road safety related to issues (liker scale)

1. Strongly disagree 2. Disagree 3. Neutral 4. Agree 5. Strongly agree

Table I-1: cause of traffic congestion in the study area

10	**The major causes of traffic congestion and problem of accessibility**	1	2	3	4	5
	Increase in personal vehicles lack of ride sharing and small number of public transports					
	Special vehicles like truck travel through the area in day times (6:00 - 10:00)					
	On street vendors					
	Reduction of road spaces due to road construction					
	Inefficient use of road network and poor design of road					
	Weak enforcement capability					
	Vehicle break down or abandoned crashed vehicles					
	Drivers lack of sense of traffic rule such as running red light, driving on the wrong side of the street, in wrong lanes or on sidewalk way, in the middle of street in rush hours to buy something from the street vendors or to give					

	ride or drop someone without caring about those behind them.					
	Lack of traffic discipline in pedestrians crossed the street in the middle of flowing traffic without using priority light system or overpasses built for them.					
	Unplanned stoppage or on street parking					
	Poor design and condition of the road					
	Creased vehicles density and vehicles population					
	Less technology, lighting, no camera					

11. Do think the under lists traffic control measures are sufficient/ adequately in this area?

Table I - 2: Existing transportation tools in the study area

Transportation tools	Strongly agree	agree	neutral	Disagree	Strongly disagree
Traffic light					
Parking restriction					
signing					
Speed control					

12. What is the effects of transportation problem on your suggestion?

☐ Impedes traffic movement ☐ Economic impact ☐ Environmental impacts

☐ Congestion and pollution ☐ All ☐ Other specific_____

13. What is level of economic effects on this transportation system area

☐ High effect ☐ Low effect ☐ Other specific_____

14. What is smart transportation on your concept

☐ Available more access

☐ Less traffic congestion with less cost

☐ Road security and involves the disable person

☐ Improved by technology

15. Do you think smart transportation has a great role for economic impacts to this area?

☐ Yes ☐ No

16. Do you believe that technology is too important for reducing traffic congestion and give access?

☐ Yes ☐ No

17. How we can practice smart transport system to this area in terms of accessibility, time management, energy management, providing of user demand, security and sustainability?

☐ By using different road dictators, camera, red light

☐ By decreasing private car and increasing public transport

☐ By intervention policy and regulation

☐ By maintain and designing the road

☐ All

18. Who is more responsible organ to apply smart transportation system

☐ Passenger ☐ Driver ☐ Government ☐Traffic police ☐ All

19. Do you want to add some suggestion about the general overall energy of this transportation system?

_____

_____

_____

_____

_____.

APPENDIX II

Auditing the physical transportation environment (checklist)

Country: Ethiopia

City/Town: Addis Ababa *Name of the study area: Megenagna, Diaspora nodal space*

Surveyed by:	Date:	Time AM/PM

Rating scale: 

Table B-1: Physical data survey checklists

Elements to check	Features to check	Yes	No	Need repair	Rating
1. Carriage way	Carriage way has no bus lane				
	Carriage way has lack of standard width and less durable road material				
	Existing roundabout has less attractive				
Other problems					
2. Walkway	The walkway is not continuous				
	Have no street furniture's, lighting and dustbin				
	Have no planted shade producing street tree				
	Walkway are blocked by street vendors and shoe shine boys				

Other problems					
3. Utilities	Do utilities have visually and environmental quality?				
	Do utility line installed appropriately?				
Other problems					
4. Street crossing	There is no crosswalk or its poorly marked				
	The intersection does not have a curb ramp for wheelchairs and walkers				
	Does the pedestrian crossing signals?				
	Traffic signals do not give enough time to cross the street.				
Other problems					
5. Transport user behaviour	Does peoples obey all traffic rules?				
	Does people aggress on informality because they are attracted by street vendor's properties?				
	Does the peoples have awareness regarding to dispose the trash on the street?				
Other problems					
	Drivers are not looking out for people walking, make unexpected turn, or seems hostile				

6. Driver's behaviour	Speed up to make it through traffic light or drove through traffic light				
Other problems					
7. On-street parking	Does the roadway have on-street parking?				
	Do they park on the street?				
8. Landscaping	Do the available plant complement the built environment?				
	Greenery is not enough to protect environmental pollution				
	Do the pedestrian walkways have green elements?				
Other problems					
9. Safety	Population density is high and makes people so stress				
	There are peoples on the streets who seems threatening				
Other problems					
10. Public transportation	Does people want to use public transport and does it enough?				
	Do the public buses have good quality?				
Other problems					
	Does street screens are exist which gives information for peoples?				

11. Technology	Does street cameras are exist in this area				
	Does traffic polices have some recording data material?				
Other problems					
12. Building orientation	Do building creates a sense of human scale?				
Other problems					
13. Node spaces	Does nodal spaces is reducing traffic congestion?				
	Nodal spaces hasn't enough ground covers				
Other problems					
14. Comfort	There are vacant lots and rundown buildings				
	The street needs bench and places to rest				
Other problems					